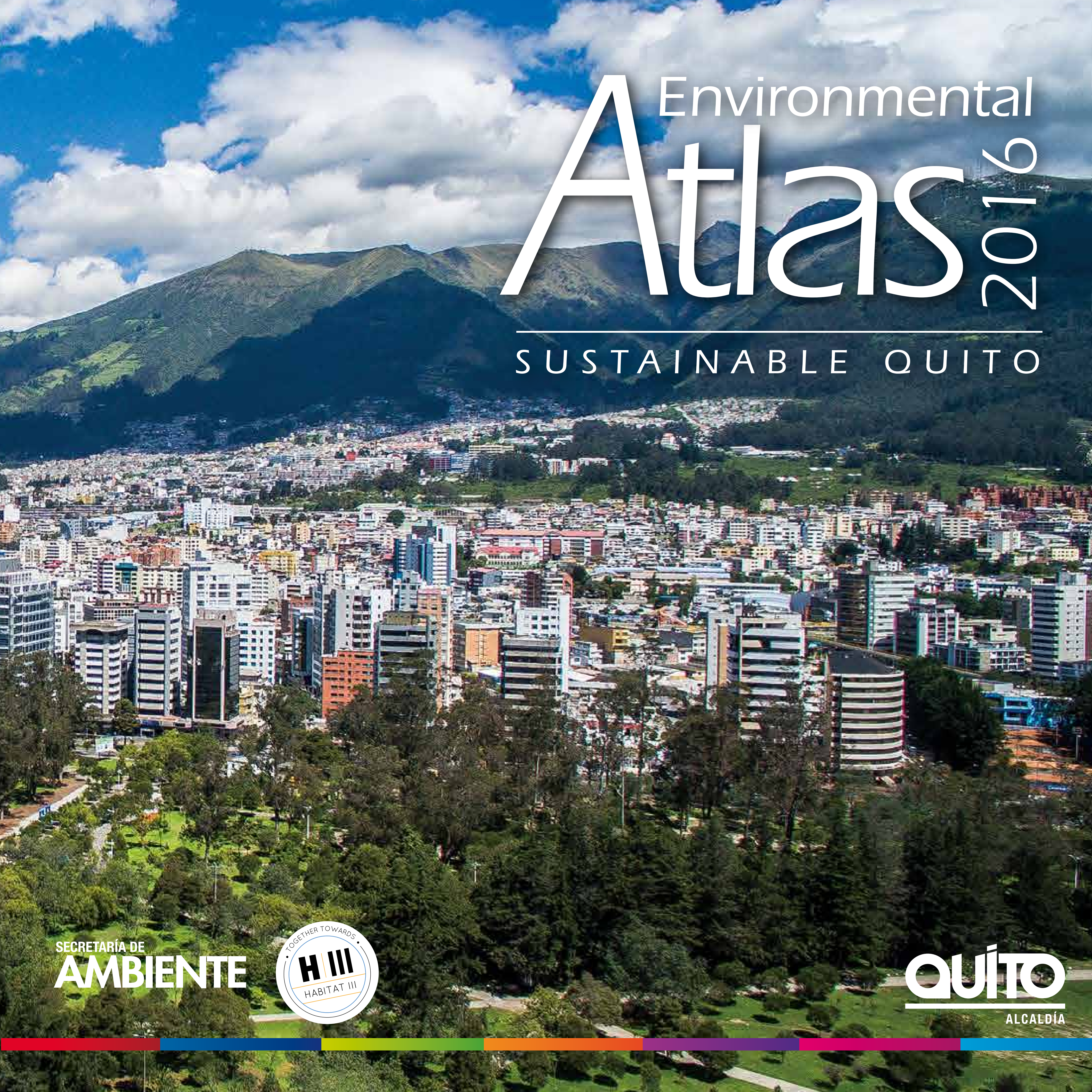
Environmental Atlas 2016

SUSTAINABLE QUITO



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QUITO ALCALDÍA

Environmental Atlas 2016

SUSTAINABLE QUITO

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Presentation

Our city vision focuses on achieving a modern and solidary Quito. A sustainable city that ensures a better quality of life to its more than 2.5 million inhabitants. In that sense, as a local government we have proposed to guide citizens towards an effective understanding of the limitations and benefits of our environment. To achieve this goal, Quito must address, with responsibility and planning, the urbanization process and climatic challenges, so that the social and economic progress of citizens is not affected.

Worldwide, and especially in developing countries, cities have grown indiscriminately, to the point that they are now responsible for the emission of more than 70% of greenhouse gases, consume 75% of global energy and generate more than 70% of waste in the world (UN-HABITAT, 2015). At this rate, the planet's capacity to meet our needs is threatened.

The Metropolitan District of Quito is experiencing situations of vulnerability in urban and rural systems. For this reason, it is our duty to change the paradigm and reinvent the city in order to live in harmony with nature. This is our proposal for Quito, conveyed by the Metropolitan Development and Territorial Management Plan 2015-2025, a roadmap for solving the pressing problems of planning and development, primarily to enhance the progress that must be realized to make ours a sustainable city.

Quito is being constructed combining the fundamental pillars of sustainable development and the manner in which the territory is ordered. Sustainable mobility is the factor that expresses the need to create more inclusive, equitable and prosperous environments. This vision of sustainability will be reflected in the third United Nations conference on housing and sustainable urban development, Habitat III, to be held in Quito in October 2016.

The Metropolitan District of Quito has defined clear policies and raised fundamental goals for the coming years on the subjects of waste, natural heritage, environmental quality, climate change and Environmental Good Practice. In short, we seek to guarantee the right of citizens to live in a healthy environment.

Meeting these objectives is no easy task, as a city with these characteristics is built over time and through the effort of its inhabitants, hence the need for an empowered and committed citizenship is essential. *The Environmental Atlas 2016 of the Metropolitan District of Quito*, which we present in these pages, is a tool enabling us to build the new urban agenda for sustainable development together.

Dr. Mauricio Rodas Espinel
Mayor of the Metropolitan District of Quito

Introduction

The natural growth and development of a city leaves traces, positive and negative and of greater or lesser impact; some of these are not so easy to cure, such as the pollution of air, water and soil, deforestation, loss of biodiversity and unplanned urban sprawl. The world's cities are seeking strategies to achieve sustainable development, development that lasts over time and does not exhaust resources or harm the environment, people and their relationships. This is only possible if there is a citizenry that is informed and committed to sustainability, essential to which is the right to timely, accurate and transparent information.

Conscious of this reality, the Metropolitan Secretary of the Environment has undertaken a participatory process to characterize, evaluate and disseminate the concept of environmental management for the MDQ, through the project 'Knowledge management, systematization and support information', financed by the Environment Fund, of which the present *Environmental Atlas 2016 of the Metropolitan District of Quito* is part.

The overall aim of this document is to transmit a wide perception of development and the environment, a vision of a sustainable city where harmony between humans and nature is paramount, showing the dynamics of the territory of the MDQ and accepting the importance of implementing new development goals and the Paris Agreement on climate change, to achieve the objectives of Habitat III and attain sustainable urban development. The *Atlas* shows the MDQ's environmental performance through indicators for urban and rural sustainability, ecological footprints, carbon and water. These indicators guide the policies, plans, programs and projects of the district.

This document reflects the five policies that form the environmental axis of the Metropolitan Development and Territorial Management Plan 2015-2025, which intend to ensure integrated waste management under the concept of 'zero waste', sustainable management of natural resources, the reduction and offsetting of the city's carbon footprint, an increase in its resilience to climate change, the quality of natural resources and the implementation of Environmental Good Practices.

The Metropolitan District of Quito has an incredible variety of ecosystems and representative species, which highlight the importance of its natural heritage, biodiversity and natural resources. However, the district's conservation is at risk. Information about the natural environment of the MDQ is complemented by maps related to topography, vegetation cover, climate zones, ecosystems, biodiversity richness and the Metropolitan System of Protected Natural Areas.

Moreover, one of the biggest challenges facing cities today is the phenomenon of climate change resulting from human activities altering the global climate system. Nowhere in the world is without this risk. It is thus important to take action to reduce emissions of greenhouse gases and detect the main threats in order to define adaptation strategies. This *Atlas* includes calculations for the district's emissions and an assessment of its vulnerability to climate change and other disasters.

The *Atlas* gathers together the actions of the Secretary of the Environment's programs which have consolidated the MDQ's local environmental management model in recent years. These actions aim to ensure the territory's local sustainability, the right of citizens to live in a healthy environment and the rights of nature, as well as promoting the principles of the sustainable city.

This document helps to guarantee the right of access of the population to environmental information and to strengthen citizen participation in the environmental management of the MDQ. The *Atlas* is a tool that allows the citizenry to get closer to their environment, and contributes to their greater influence over the actions and decisions related to environmental issues, so that together we will make Quito a sustainable city.

Dra. Verónica Arias Cabanilla
Metropolitan Secretary for the Environment

Prologue

Since time immemorial, the phenomenon of human agglomeration known as the concept of urbanization has defined a particular form of relationship with nature; this has been understood as possessing both creative and destructive potential.

The establishment of human settlements unleashes a relentless dynamic of innovation that contrasts with the passivity of rural life. Urban conurbations are venues for meeting and for creating culture, civility and knowledge, transforming nature for the purpose of increasing the capacity of human reproduction. As such, nature appears to provide a large reservoir of resources to be exploited, this relationship deepened rapidly and had its most decisive boost with the deployment of the capitalist economy, with modernity and globalization, to the point of putting the replenishment of ecosystems at risk.

Based on taking advantage of the useful effects of agglomeration, population growth in the cities involved the anarchic expansion of the urban area, along with the corresponding negative effects: depopulation of the countryside, deforestation and environmental pollution. The modern perspective on nature highlights problems: a sense of catastrophic vulnerability is associated with phenomena such as climate change and the limited resilience of life systems in natural environments, including human life.

The area which today is known as the Metropolitan District of Quito is also exposed to these social and environmental complexities. With the clear intention of addressing these complexities through the deployment of a rigorous scientific methodology, the Secretary of the Environment of the Metropolitan District of Quito now presents the *Environmental Atlas 2016 of the MDQ*, an indispensable tool for designing and sustaining policies of long term impact on the reality of Quito's territory, aiming towards the consolidation of a sustainable city resilient to climate change. The publication of knowledge in this work constitutes a fundamental support for municipal public policy, in that it requires the coordinated work of various bodies as well as the intelligent and active participation of citizens.

The *Atlas* accurately describes the social and environmental characteristics of the Metropolitan District of Quito's territory: an area of 423,074 ha crossed by the equator, with altitudes ranging from 500 to 4,780 meters, and a variety of valleys and mountains that create various types of climate: tropical humid in the bioregion of el Chocó, semi-dry in the inter Andean valleys, and hyper humid in the Andean mountain foothills and moors of the Cordilleras Occidental and Real, with temperatures ranging from -2 C to 27°C and rainfall between 350 mm/yr and 4,500 mm/year with 75% relative humidity. These factors shape a diversity of ecosystems and habitats ranging from permanent glaciers, wet and dry moorland paramos, montane forests, dry valleys and evergreen piedmont forests, with a concentration of wild flora and fauna comparable with the levels of diversity in tropical Amazonian areas. Of the seventeen types of existing ecosystems in the district eight are forest formations, three are shrublands and six are grasslands. Sixty percent of the territory is covered by natural vegetation, almost thirty percent is cultivated and ten percent is occupied by built-up areas.

The *Atlas* highlights that Quito, more than being a city, is a vast territory with diverse landscapes where the human is interwoven with the natural environment in a millennia-long history which is now known through the diligent scientific research work of geographers, archaeologists, anthropologists, biologists,

historians, sociologists and economists, using multi-disciplinary approaches on which an appropriate policy of institutional intervention can be formed. The sustained research on which this book is based makes it possible to propose clear objectives and specific intervention strategies that can reduce the harmful effects of the urban phenomenon while also enhancing the benefits of agglomeration logic in the city.

Studies such as this *Environmental Atlas* permit us to think of a city that has the ability to adequately combine elements of the concept of resilience, defined as the systemic capacity to adapt and respond to crisis situations. At the urban level, the concept of resilience refers to the ability of cities to prevent, act and recreate against external or internal threats, proactively focusing on their causes, thereby safeguarding the lives and property of inhabitants. Urban resilience requires long term planning able to identify risk factors and reduce the costs of addressing environmental crises, the key objective being to face with clarity and decisiveness the necessary transition to a radical change in consumption patterns.

This concept is closely related to sustainability, which refers to the ability of a system to develop without compromising resources and possibilities for future generations. The principle supporting this concept is that the planet's natural resources are limited and therefore any development process intended to be sustainable must take into account its impact on the environment, its viability over time and its contribution to reducing inequities. In the case of urban sustainability, we are talking about building cities of integral wellbeing, that make considerable advancement in improving their quality of life indices with the capacity for integrated and farsighted governance that will enable the transition to a new development model.

As already indicated, the *Environmental Atlas* provides a comprehensive description of the Metropolitan District of Quito in terms of its climate, ecosystem and biological diversity, as well as the anthropogenic elements of population growth and socio-economic dynamics, highlighting the urgent need for conservation and improved environmental management. This analysis is performed on the basis of a series of indicators which take up proposals for international statistical measurement (index of green cities, ecological footprint, water footprint, carbon footprint) and adapt them to the local context.

Sustainable city indicators, structured in an interdisciplinary way, include a multiplicity of quantitative and qualitative variables designed to assess the environmental performance of the district, from both an urban and a rural perspective. This evaluation is operationally focused to determine the environmental impacts of the ecological, water and carbon footprints corresponding to the regenerative capacity of nature, the state of water resources and the emissions contributing to climate change respectively.

The overall balance of the detailed results presented in this book manifest two situational states: globally in relation to Latin America cities of the Green City Index (Siemens, 2013), the Metropolitan District has an average environmental performance, showing appropriate urban management related to water, energy, solid waste management, transportation and air quality throughout the year. Yet despite having a wide "sewerage" network the district is deficient in relation to the treatment of sewage for final disposal. In rural areas, the district is within ecological and water footprint limits, with appropriate management for the conservation of natural areas and water sources, as well as the implementation of measures for mitigation and adaptation to climate change in the areas of: agriculture, forest fires, water supply, sustainable buildings and land use change.

In light of this scenario, and beyond isolated interventions, the horizon towards which the city is being directed is that of integrated sustainability. This text draws a precise and synthetic summary of the inter-

national agreements and regulatory frameworks that have led to the formulation of sustainable management policy and are currently embodied by the 'Agenda for Sustainable Development 2030', proposed by the United Nations. The Municipality of Quito, consistent with this policy, has proposed the implementation of a series of environmental criteria related to the urban development of the district, this text details these criteria and provides a didactic specification of the benefits of their implementation in improving the quality of life for Quito's inhabitants.

Of course, the theoretical, methodological and practical development presented here, is directed towards the design of Environmental Policies for an Intelligent City. This corresponds to the title of the last section of this *Atlas*, which is based on the axes of economy, environment and society, with policies attempting to influence the causes of vulnerabilities, manifested as critical points in the index of environmental management of the city. Policies for waste management, the management of natural heritage (Urban Green Network), confronting climate change (including the management of mobility, water resources and sustainable agriculture), management of environmental quality, and for Environmental Good Practices are presented in this section, each with a description of their respective stages and the processes to be completed.

The publication of the *Environmental Atlas* makes available knowledge and a public policy proposal that should be the object of analysis and social mobilization for individual and collective actors of the district. It represents an opportunity to be aware of the impacts of everyday practices on the territory of the district, and of the need to act decisively on reducing the climate footprint and on conserving natural heritage in order to guarantee its survival for current and future generations. The *Atlas* calls for the active and intelligent participation of citizens for the achievement of these goals.

Julio Echeverría
City Institute of the Metropolitan District of Quito

Part I

NATURAL AND ANTHROPOGENIC ENVIRONMENT OF THE MDQ

The Metropolitan District of Quito (MDQ) is a natural mosaic of diverse landscapes formed between valleys and mountains generating a range of climates and biodiversity. Its urban environment, which dates back to the time of the Kitu-Kara civilization, has an ancient and immense cultural diversity. A privileged position in the Spanish colonial empire has left a legacy of cultural heritage that, fused with the modern, gives a special identity to its citizens. Narváez Nixon 2016

Panoramic view of Quito with the Virgin of the Panecillo in the foreground.

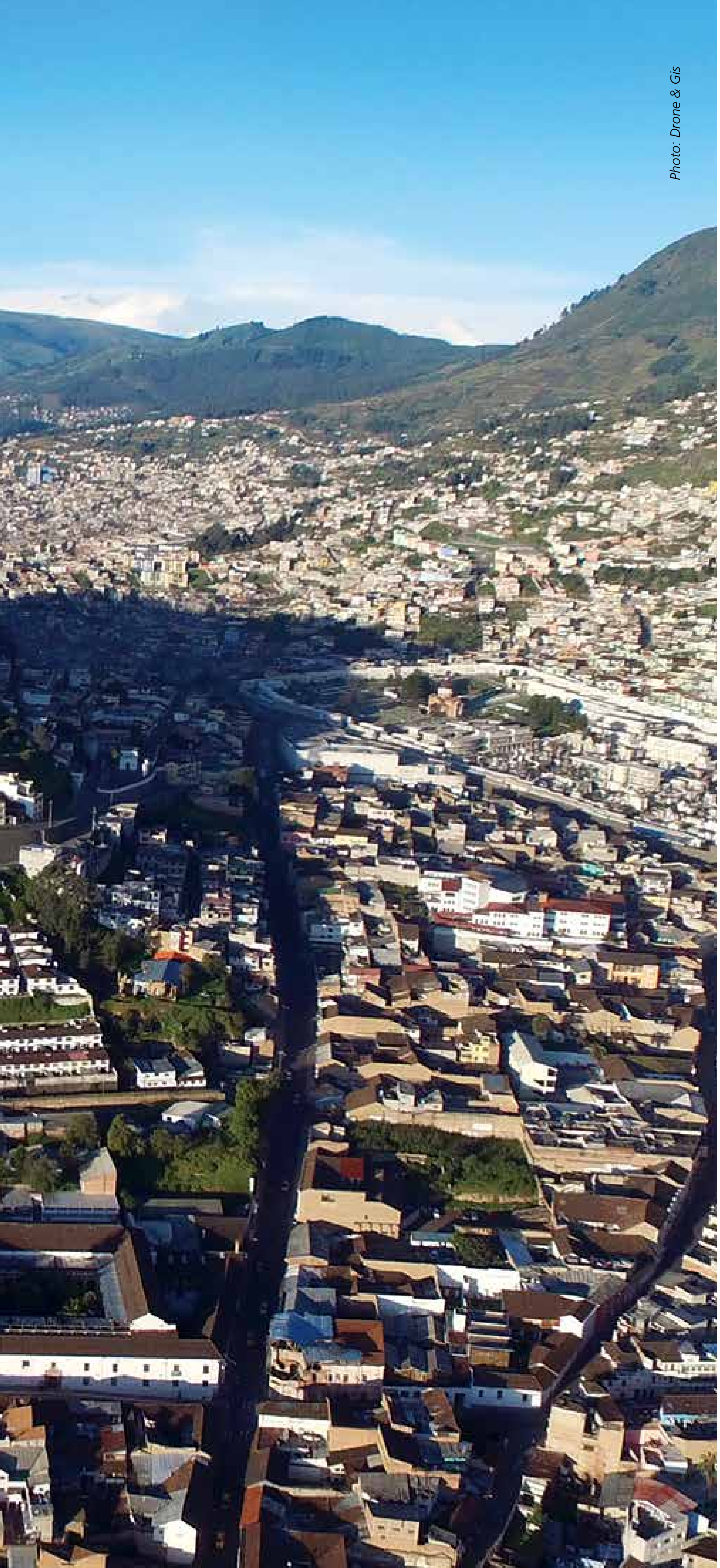


Photo: Drone & Gis

QUITO, MIDDLE OF THE WORLD

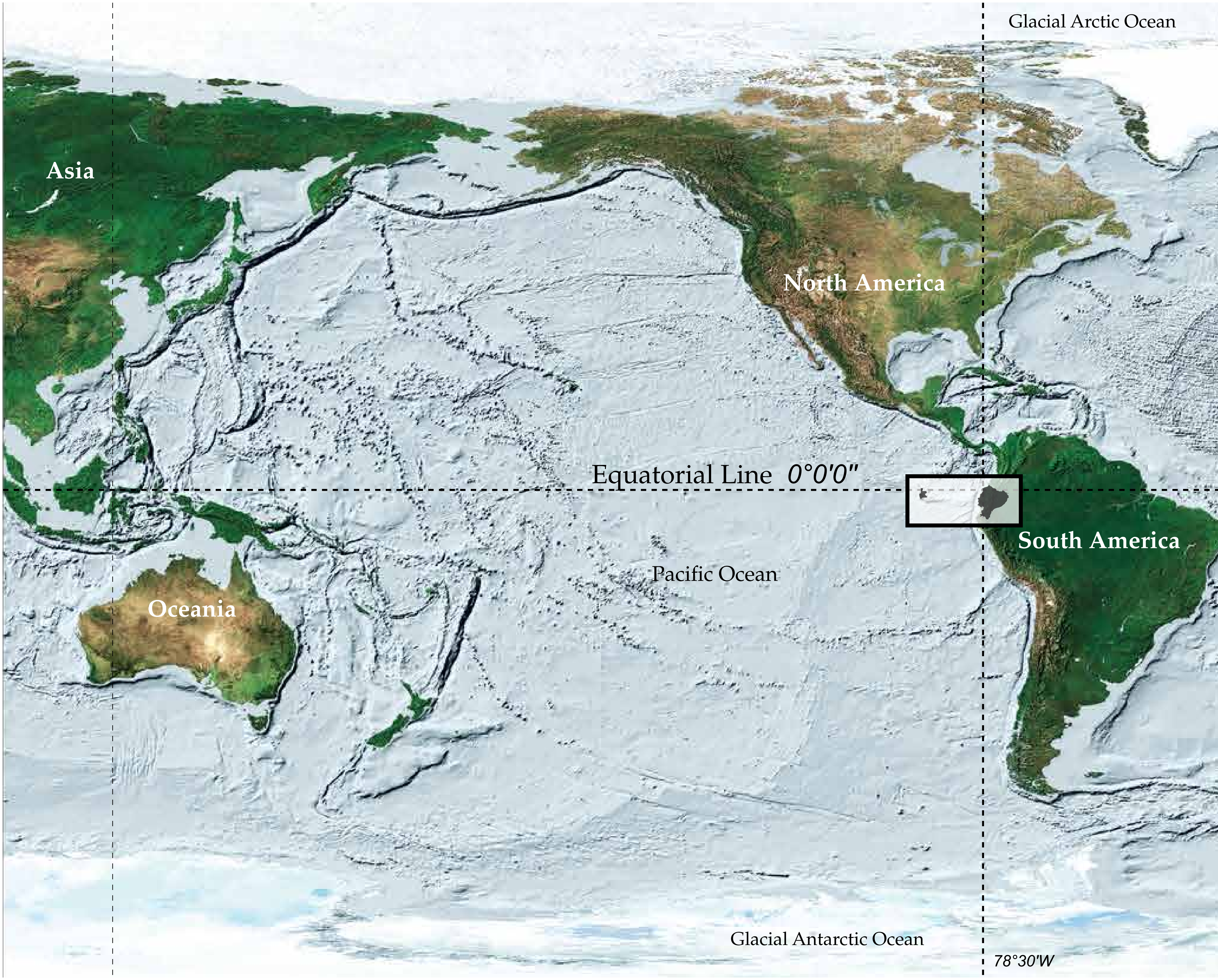
The Metropolitan District of Quito was created on December 27th 1993; the city is the political capital of Ecuador and has a privileged place in the global environment. Surrounded by mountains, it lies at a height ranging between 500 and 4,780 meters above sea level (masl) and is crossed by the equator, which places it in the 'middle of the world' (*map 1*). This feature creates unique climatic qualities providing a wide biodiversity. Its natural and cultural wealth and the syncretism between colonial and modern expressed in its unique architecture are the reasons for which Quito has been a World Cultural Heritage Site since 1978.

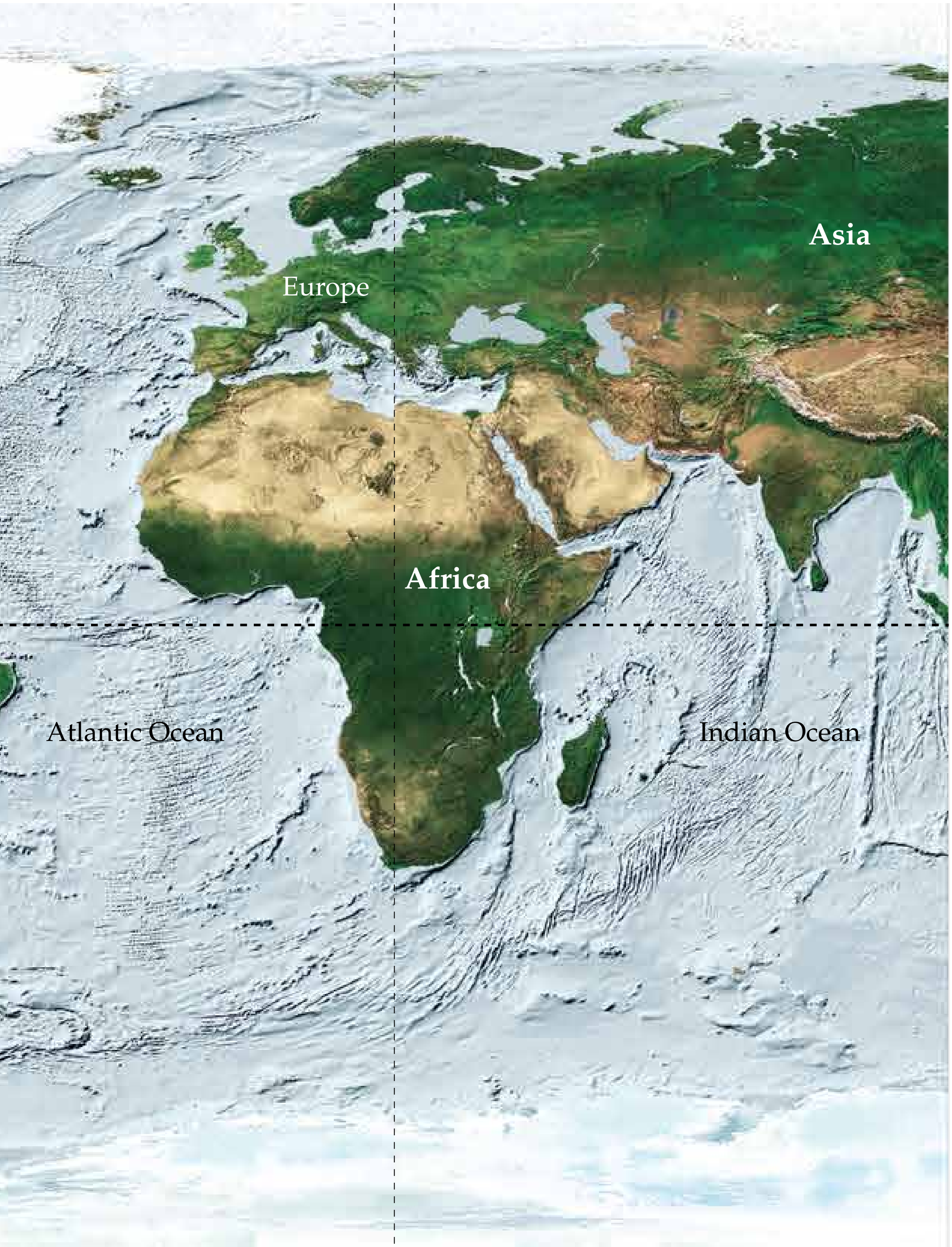
Quito is host to the Third United Nations Conference on Housing and Sustainable Urban Development - 'Habitat III', which aims to establish guidelines for the construction of equitable, prosperous, resilient, secure and sustainable cities, in order to revitalize the global commitment to achieving sustainability of human settlements, focusing on the implementation of a 'new urban agenda'.

Quito constitutes a mega-diverse district whose biological wealth and landscape of cloud forests, ravines and moors guard a treasure, natural heritage from millions of years of evolution in the presence of the Andes, maintaining intact sanctuaries and refuges for orchids, carob trees, hummingbirds, condors, howler monkeys, spectacled bears, among others, which are preserved, protected and recovered as the Natural Heritage of the Metropolitan District of Quito.

> *"The city of Quito forms a unique ensemble sui generis where nature and man are brought together to create a work unique and transcendental of its kind".*
>
> UNESCO, 1978.

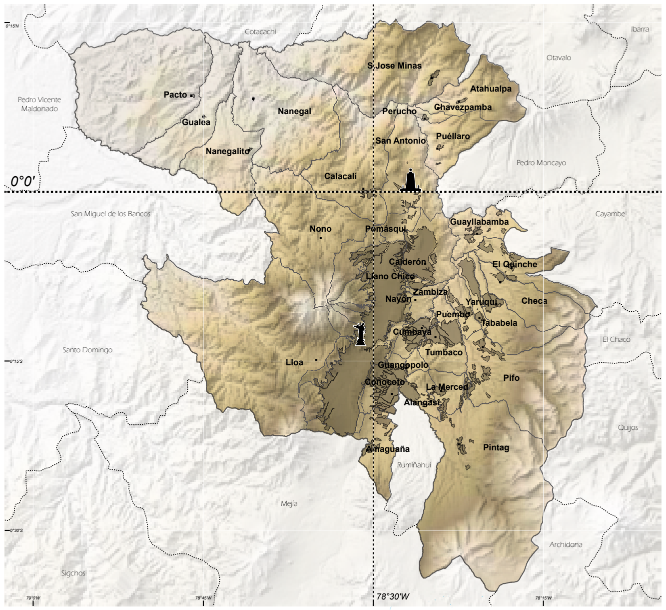
Map 1 Geographic position of Quito in the world





Continental Ecuador

Metropolitan District of Quito



LANDSCAPE DIVERSITY

Topography

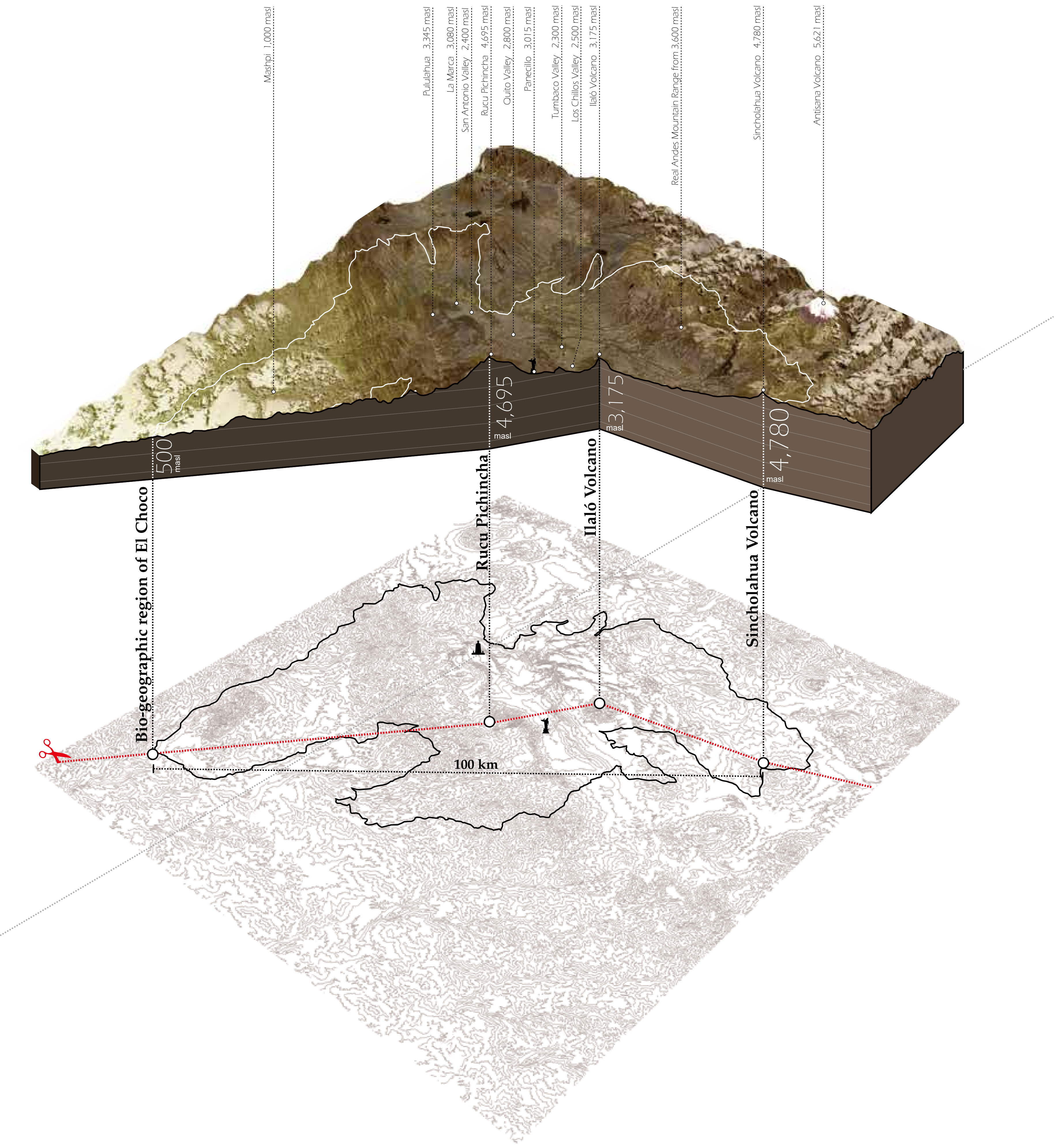
The Metropolitan District of Quito (MDQ) has a total area of 423,074 ha distributed at an altitudinal range from 500 to 4,780 meters above sea level, these altitudinal extremes being 100 km apart on a straight line (see *Map 1*). This large gradient forms part of the Guayllabamba basin, characterized by a variety of valleys and mountains that directly influence the different types of climate: tropical humid in the bioregion of Chocó, semi-dry in the Andean valleys, hyper-humid in the mountain foothills and moors of the Occidental and Real Andean mountain ranges.

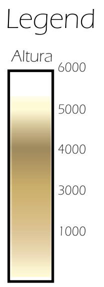
The integration of geological formations and climates affords the configuration of ecosystems and habitats unique to the MDQ, characterized by large tracts of rainforests exceeding 120,000 ha to the west of the city of Quito: shrubland and dry forests concentrated in 47,000 ha in the Guayllabamba basin; humid shrubland distributed in ravines and intervening areas with an expanse of 45,000 ha; and some of the highest moors in the world starting at 3,600 meters above sea level, located in the Occidental and Real Andean mountain ranges covering an area of 45,000 ha.


San Antonio de Pichincha, La Marca mount, from the MDQ.

Photo: Anaís Córdova-Páez

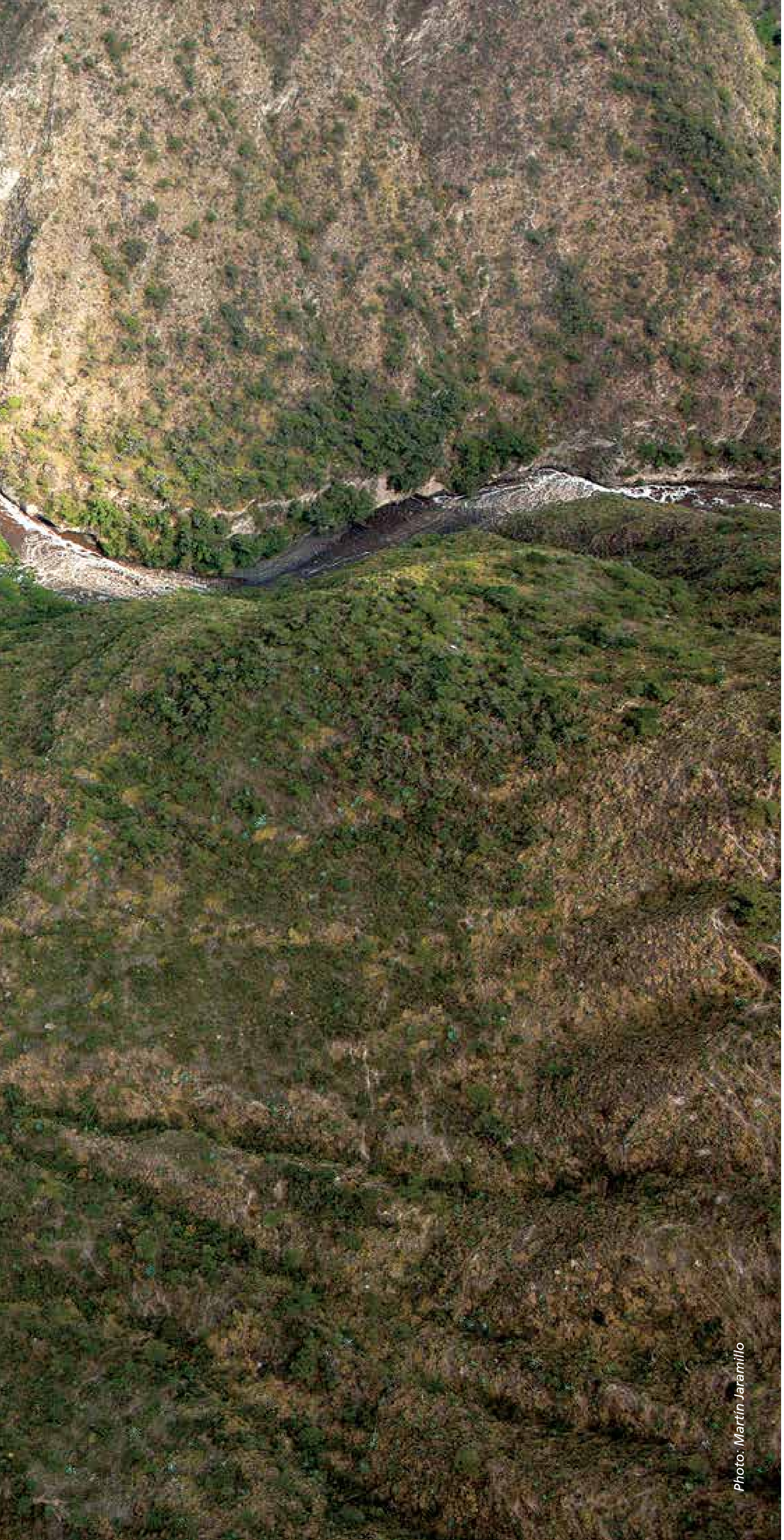
Infographic 1. MDQ orography





The outstanding areas in the district are: the Quito valley, at 2,800 masl; Los Chillos, at 2,500 masl; San Antonio, at 2,400 masl; Tumbaco, at 2,300 masl and the foothills of the Western mountain range at 1,200 masl (northwest of the MDQ). Among the highest mountains are the volcanoes: Sincholahua, 4,780 masl; Pichincha, 4,695 masl; Atacazo, 4,400 masl, and Mojanda at 4,198 masl; among the lower volcanoes and elevations are: Coturco, at 3,560 masl; Pululahua at 3,345 masl; Ilaló at 3,175 masl; the Panecillo, 3,015 masl; La Marca, 3,080 masl; and Catequilla, at 2,636 masl, creating a unique landscape identity.

The San Pedro River stands out in the orographic landscape.

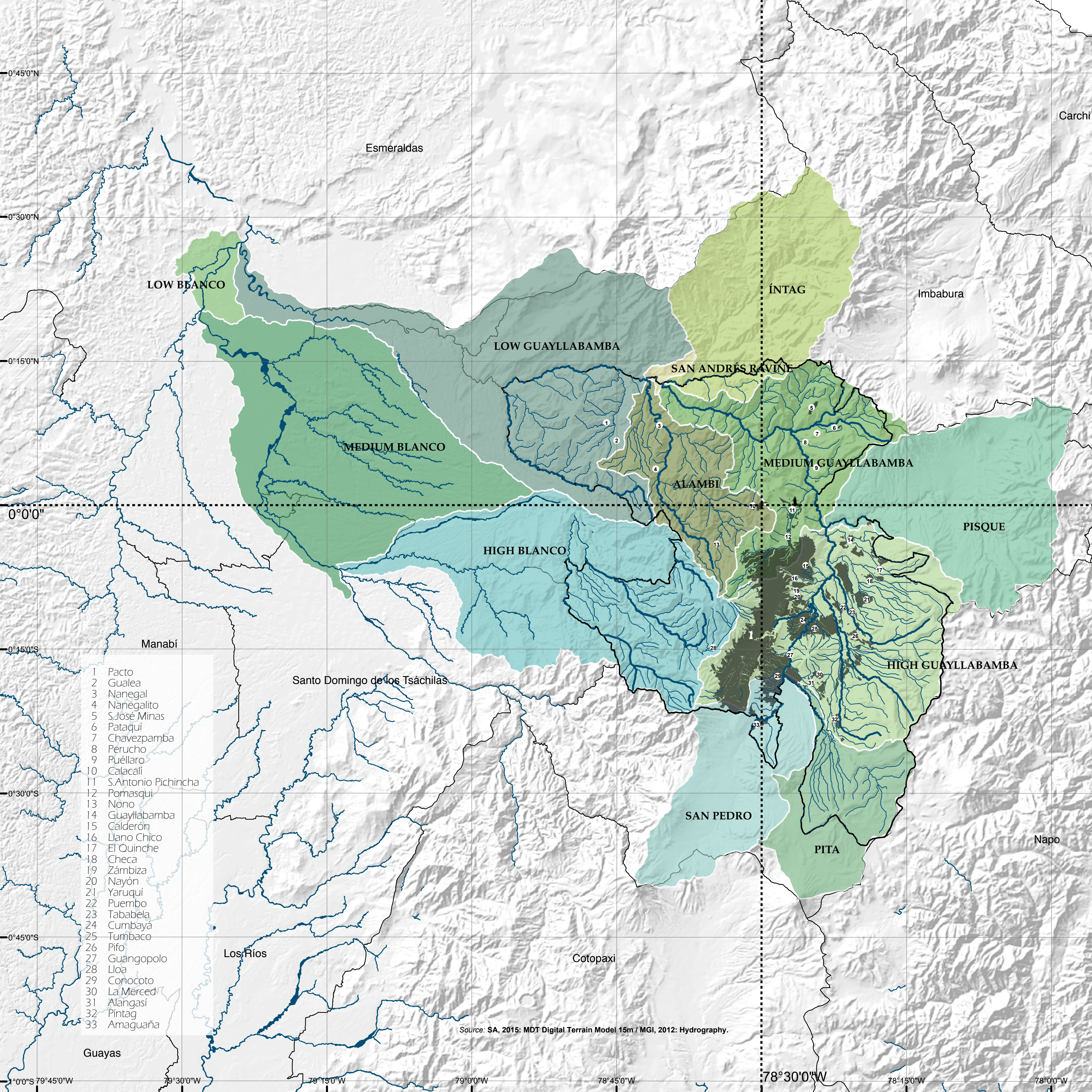


Hydrography

The Metropolitan District of Quito is located in the basin of the Esmeraldas River, whose source is the melting snow and slopes of the Cayambe, Sincholagua, Cotopaxi, Illiniza, Atacazo and Pichincha mountains. These slopes descend to the west and form the Guayllabamba and BlancoWhite rivers, which together with the Quinindé River are the main sub-basins that form the Esmeraldas River Basin (*Map 2*). The drainage area of this basin is 11,792 km2 and represents 5% of the national territory.

Table 1 shows the physical characteristics of the basins and sub-basins of the Guayllabamba and Blanco rivers.

Within the Metropolitan District of Quito, the water from natural sources is divided into rivers and/or streams and lagoons. The first category represents 0.11% of the MDQ with an area of 481 hectares, and the lagoons cover an area corresponding to 0.05% of the district, equivalent to 208 hectares. Water from artificial sources represents 0.02% (67 hectares) and comes from reservoirs for storage and purification.



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78°30'0"W
78°15'0"W
78°0'0"W
Esmeraldas
Carchi
Imbabura
Manabí
Santo Domingo de los Tsáchilas
Los Ríos
Cotopaxi
Napo
Guayas
LOW BLANCO
LOW GUAYLLABAMBA
ÍNTAG
SAN ANDRÉS RAVINE
MEDIUM BLANCO
MEDIUM GUAYLLABAMBA
ALAMBI
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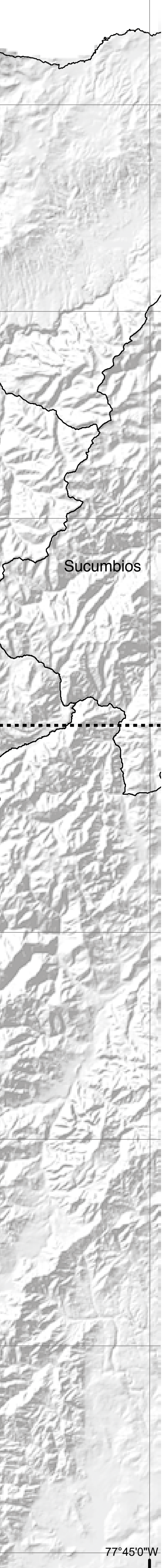
SAN PEDRO
PITA
1 Pacto
2 Gualea
3 Nanegal
4 Nanegalito
5 S.José Minas
6 Pataquí
7 Chavezpamba
8 Perucho
9 Puéllaro
10 Calacalí
11 S.Antonio Pichincha
12 Pomasqui
13 Nono
14 Guayllabamba
15 Calderón
16 Llano Chico
17 El Quinche
18 Checa
19 Zámbiza
20 Nayón
21 Yaruquí
22 Puembo
23 Tababela
24 Cumbayá
25 Tumbaco
26 Pifo
27 Guangopolo
28 Lloa
29 Conocoto
30 La Merced
31 Alangasí
32 Pintag
33 Amaguaña
Source: SA, 2015: MDT Digital Terrain Model 15m / MGI, 2012: Hydrography.



Map 2

Sub-basins of the Guayllabamba and Blanco rivers

Table 1. Physical characteristics of the basins and sub-basins of the Guayllabamba and Blanco rivers

Name	Height (masl)	Area (km²)	Perimeter (km)	Main riverbed length (km)	S riverbed (%)	S basin (%)	Compactness coefficient (Kc)	Form factor (Kf)
Level 4 Guayllabamba								
Guayllabamba	60	8239	670	312.6	0.8	38.4	2.1	0.4
Level 5 Guayllabamba								
Low Guayllabamba	60	1907	295	125.5	0.4	29.7	1.9	0.3
Alambí	720	550	144	67.6	3.4	57.9	1.7	0.3
San Andrés ravine	720	29	31	14.1	5.6	54.0	1.6	0.3
Íntag	800	1044	154	70.6	3.2	51.4	1.3	0.4
Medium Guayllabamba	800	878	200	82.6	2.2	5.4	1.9	0.5
Pisque	1840	1127	172	78.2	2.0	35.5	1.4	0.4
High Guayllabamba	1840	1359	186	69.3	2.1	35.6	1.4	0.7
Pita	2440	592	141	59.6	2.7	26.7	1.4	0.4
San Pedro	2440	751	140	70.1	1.5	27.2	1.4	0.3
River Blanco								
Blanco	60	3553	397	193.4	0.7	30.3	1.9	0.3
Level 4 River Blanco								
High Blanco	320	1659	232	94.7	1.8	48.5	1.6	0.3
Medium Blanco	80	1743	216	79.2	0.3	25.4	1.4	0.5
Low Blanco	60	151	61	19.4	0.1	17.0	1.4	0.6

Source: Secretary of the Environment, designed by the metropolitan network for the quality of water resources, 2012.

Legend

- Guayllabamba low
- Alambi
- Quebrada San Andrés
- Medium Guayllabamba
- Pisque
- Íntag
- High Guayllabamba
- Pita
- San Pedro
- High Blanco
- Medium Blanco
- Low Blanco

CLIMATIC DIVERSITY

The MDQ has a wide altitudinal variation (500-4780 masl), which equates to a warm equatorial zone with 75% relative humidity and an average temperature of 14.78°C (UNEP et al, 2011).

The influence of trade winds causes almost year round rainfall. However, there is a marked variation as some areas have less than 400 mm per year rainfall and others have an annual precipitation greater than 4,500 mm.

Over the past 30 years climate change in the MDQ has become evident through increasing temperatures and the distribution and intensity of rainfall.

Map 3 displays monthly rainfall and temperatures from 1960 to 1990 with figures projected to 2050. The temperature variation ranges from 2.3 to 2.5°C, while in terms of precipitation there is no great variation. Based on the figures for rainfalls— yearly rainfall average - and average yearly historical and projected temperatures, we can determine 11 types of climate for the MDQ, these are defined in *Table 2*, *Map 4* and Figure 1.

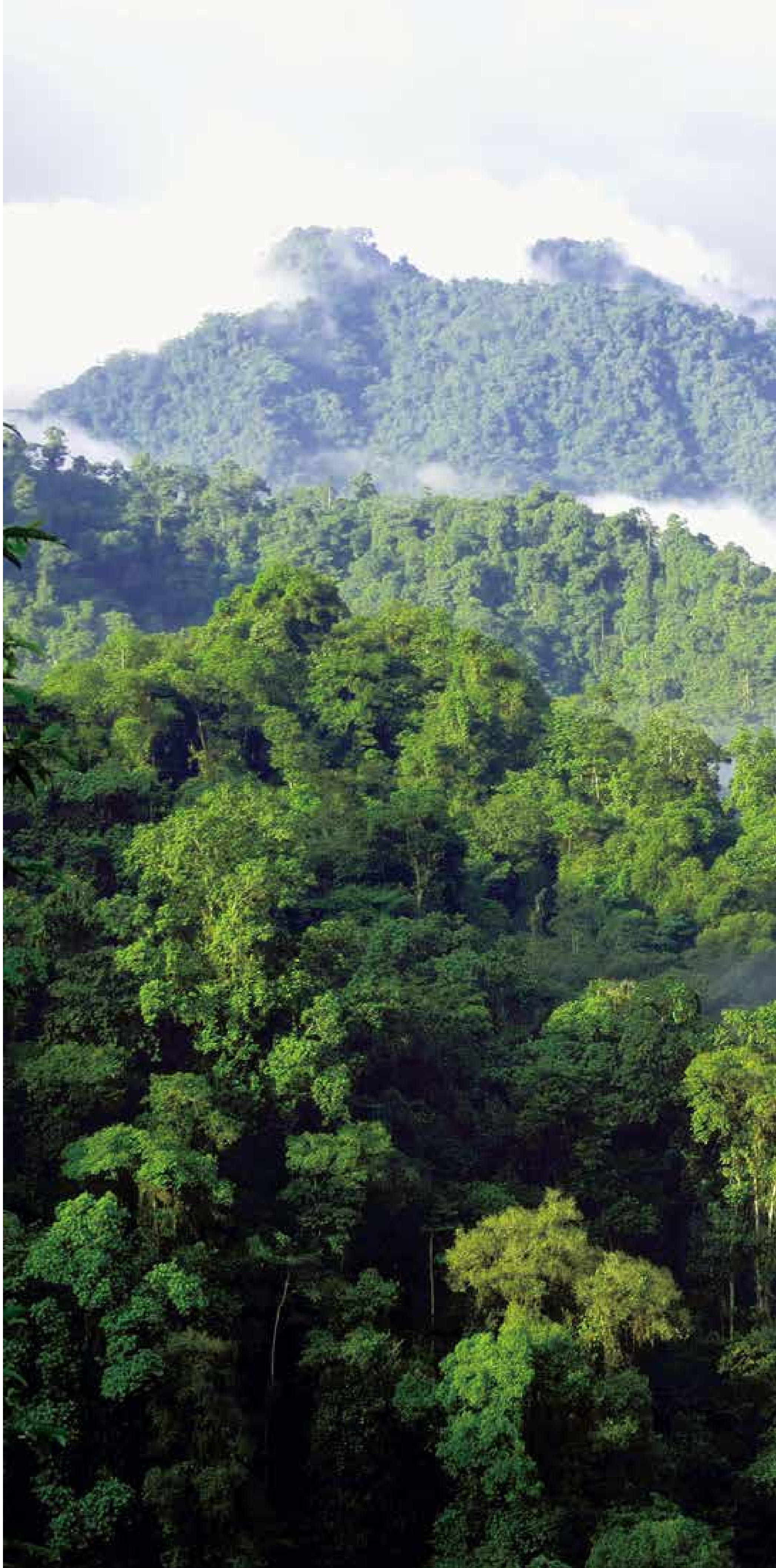


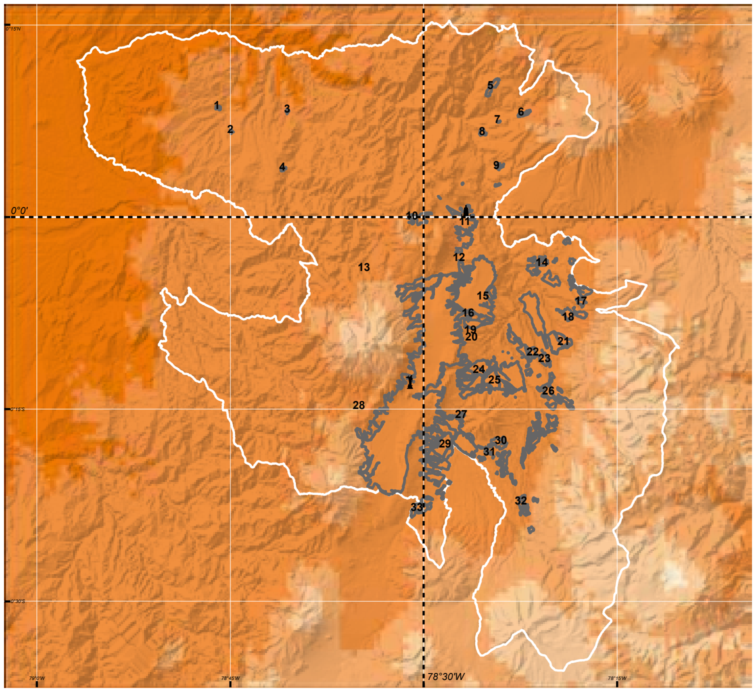

Photo: Germán Toasa

Mashpi.

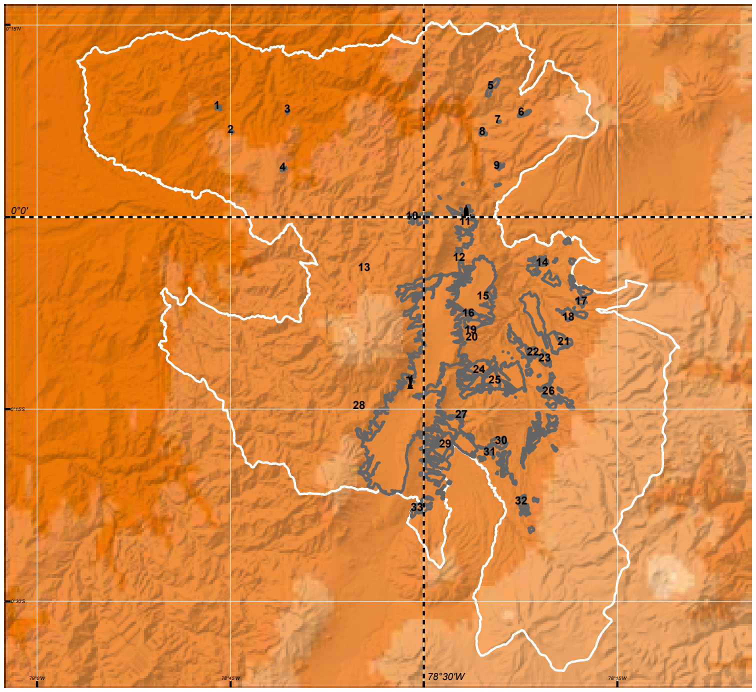
3 Map

Rainfall and temperatures 1960-1990 and figures projected to 2050

Multiannual average temperature 1960-1990

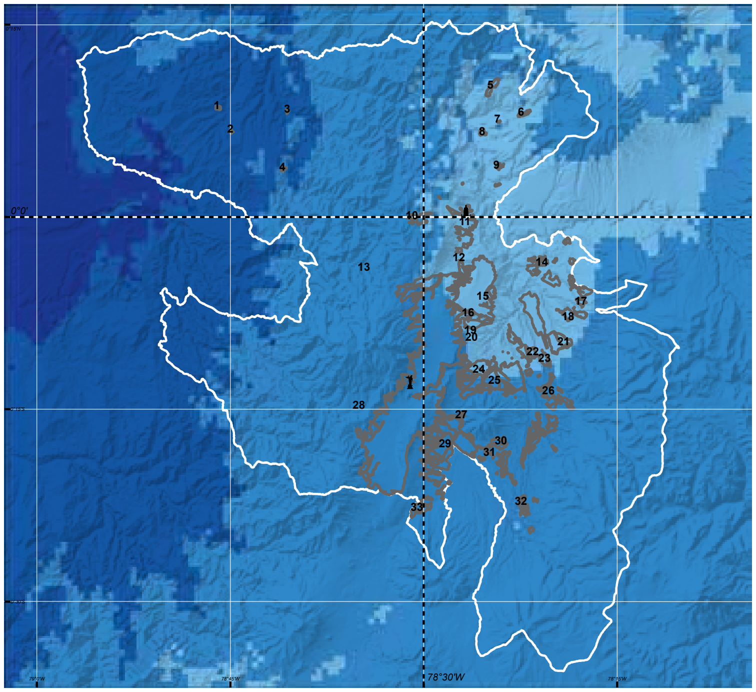


Multiannual average temperature to 2050

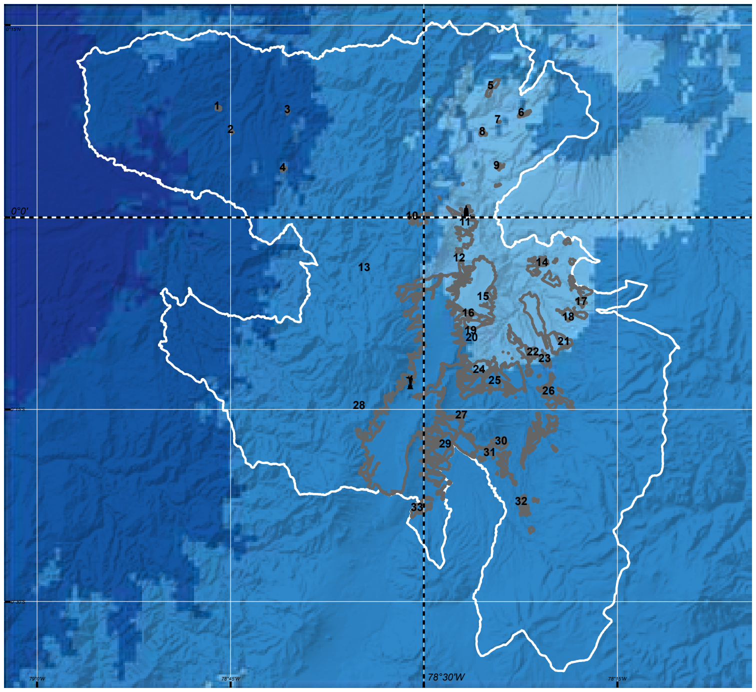


Less than 0
0 - 5
5 - 10
10 - 20
20 - 30

Multiannual average rainfall 1960-1990



Multiannual average rainfall to 2050

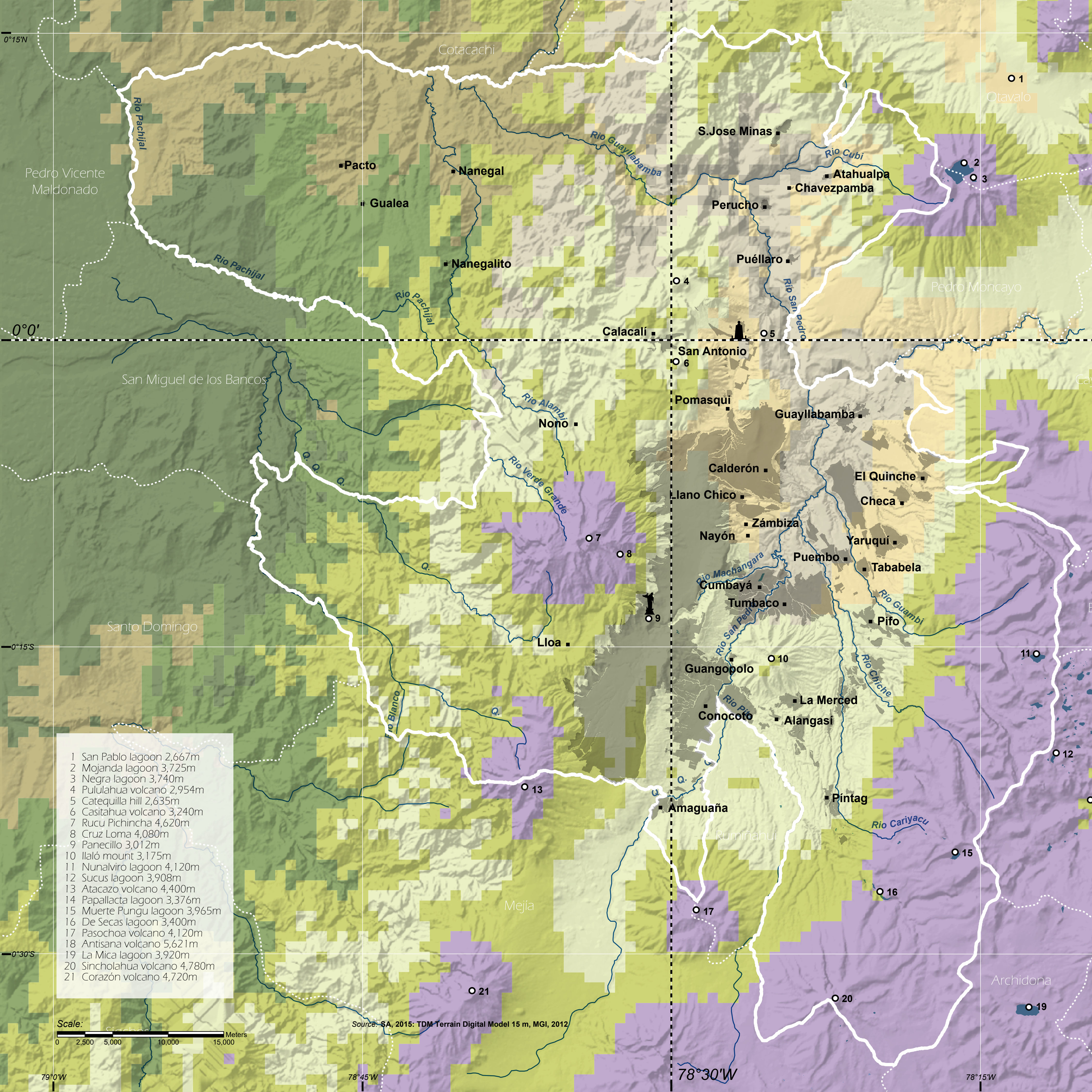


453 - 500
500 - 1,000
1,000 - 2,000
2,000 - 3,000
Higher than 3,000

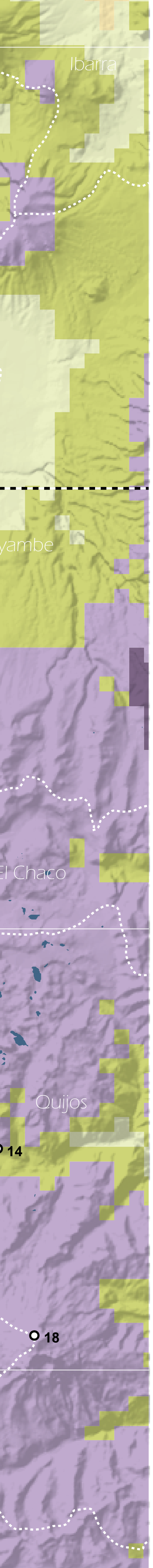
1 Pacto
2 Gualea
3 Nanegal
4 Nanegalito
5 S.José Minas
6 Atahualpa
7 Chavezpamba
8 Perucho
9 Puéllaro
10 Calacalí
11 S.Antonio de Pichincha
12 Pomasqui
13 Nono
14 Guayllabamba
15 Calderón
16 Llano Chico
17 El Quinche
18 Checa
19 Zámbiza
20 Nayón
21 Yaruquí
22 Puembo
23 Tababela
24 Cumbayá
25 Tumbaco
26 Pifo
27 Guangopolo
28 Lloa
29 Conocoto
30 La Merced
31 Alangasí
32 Pintag
33 Amaguaña

Independence Plaza, view of the Quito Cathedral

Photo:Metropolitan News Agency



0°15'N
0°0'
0°15'S
0°30'S
79°0'W
78°45'W
78°30'W
78°15'W
Cotacachi
Otavalo
Pedro Vicente Maldonado
Pedro Moncayo
San Miguel de los Bancos
Santo Domingo
Mejía
Rumiñahui
Archidona
Río Pachijal
Río Guayllabamba
Río Cubi
Río San Pedro
Río Alambi
Río Verde Grande
Río Machangara
Río Guambi
Río Chiche
Río Pita
Río Cariyacu
Río Blanco
Q.
Pacto
Nanegal
Gualea
Nanegalito
S.Jose Minas
Atahualpa
Chavezpamba
Perucho
Puéllaro
Calacalí
San Antonio
Pomasqui
Nono
Guayllabamba
Calderón
El Quinche
Llano Chico
Checa
Zámbiza
Nayón
Yaruquí
Puembo
Tababela
Cumbayá
Tumbaco
Pifo
Lloa
Guangopolo
La Merced
Conocoto
Alangasí
Amaguaña
Píntag
1 San Pablo lagoon 2,667m
2 Mojanda lagoon 3,725m
3 Negra lagoon 3,740m
4 Pululahua volcano 2,954m
5 Catequilla hill 2,635m
6 Casitahua volcano 3,240m
7 Rucu Pichincha 4,620m
8 Cruz Loma 4,080m
9 Panecillo 3,012m
10 Ilaló mount 3,175m
11 Nunalviro lagoon 4,120m
12 Sucus lagoon 3,908m
13 Atacazo volcano 4,400m
14 Papallacta lagoon 3,376m
15 Muerte Pungu lagoon 3,965m
16 De Secas lagoon 3,400m
17 Pasochoa volcano 4,120m
18 Antisana volcano 5,621m
19 La Mica lagoon 3,920m
20 Sincholahua volcano 4,780m
21 Corazón volcano 4,720m
Scale:
0 2,500 5,000 10,000 15,000 Meters
Source: SA, 2015: TDM Terrain Digital Model 15 m, MGI, 2012



4 Map
Climate levels of the MDQ

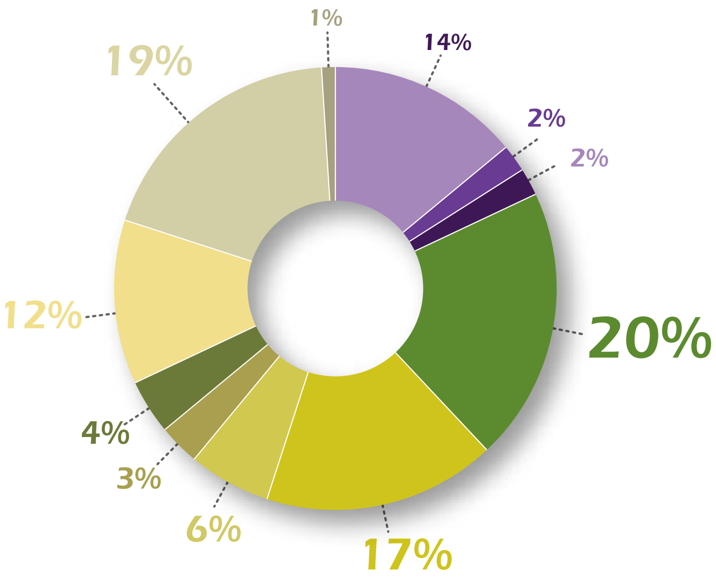


Figure 1. Climate levels projected to 2050.

Projected climate 2050

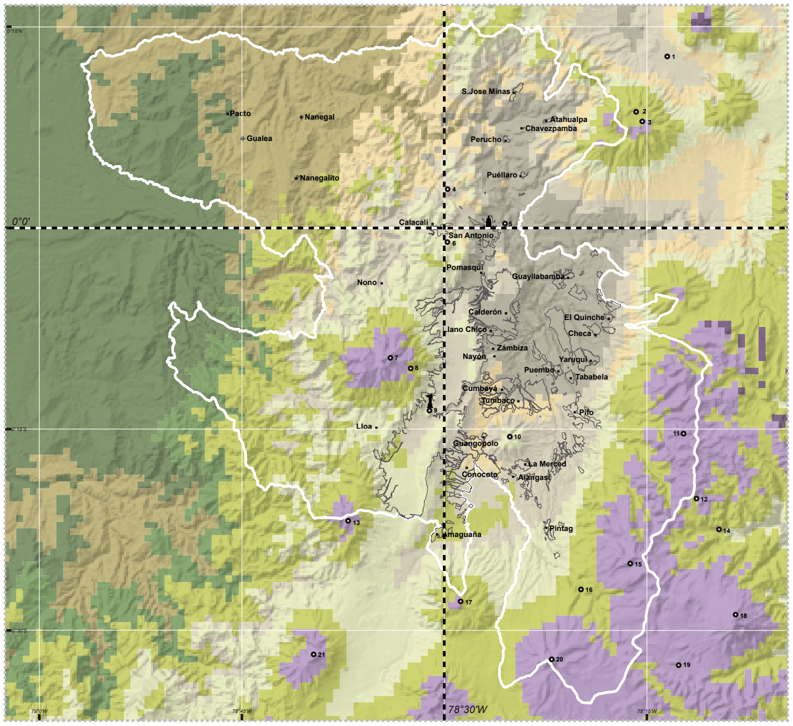


Table 2. Types of Climate in the MDQ

Climate	Precipitation (rainwater mm)	Temperature (Centigrade °C)	Terrain, Gradient	Elevation range (masl)
Very humid montane	between 2,000 and 3,000 mm	between 8 and 19 °C	Terrain: Montane Gradient: Steep	between 1,200 and 3,700
Humid montane	between 1,000 and 2,000 mm	between 8 and 14°C	Terrain: Narrow montane Gradient: Steep	between 1,800 and 1,200
Semi-humid montane	between 1,000 and 2,000 mm	between 8 and 13 °C	Terrain: Sloping montane Gradient: Steep to moderate	between 1,800 and 1,200
Semi-dry montane	between 1,000 and 2,000 mm	between 14 and 16 °C	Terrain: Sloping montane Gradient: Moderate	between 3,600 and 2,700
Dry montane	between 500 and 1,000 mm	between 8 and 18 °C	Terrain: Hilly montane Gradient: Moderate to gentle	between 2,700 and 2,200
Very dry montane	less than 500 mm	more than or equal to 13 °C	Terrain: Inter Andean valley Gradient: Gentle	between 2,800 and 1,600
Very humid paramo moor	more than 2,000 mm	less than or equal to 7 °C	Terrain: Montane Gradient: Moderate	between 4,400 and 3,600
semi-humid paramo moor	between 1,000 and 2,000 mm	less than or equal to 7 °C	Terrain: Montane Gradient: Moderate	between 4,800 and 3,600
Humid paramo moor	less than 1,000 mm	less than or equal to 7 °C	Terrain: Montane Gradient: Moderate	between 4,300 and 3,600
Tropical	between 2,000 and 3,000 mm	more than or equal to 20 °C	Terrain: Narrow piedmont Gradient: Moderate	between 1,400 and 1,000
Very humid tropical	more than 3,000 mm	more than or equal to 18 °C	Terrain: Sloping piedmont Gradient: Moderate to slight	between 1,000 and 500

Source: Secretary of the Environment, Study of vulnerability to climatic change, 2014

ECOSYSTEMS

There are 17 types of ecosystem in the MDQ. According to the classification system provided by NatureServe, the remaining vegetation with the greatest coverage is found in the northwest of the district and corresponds to the montane rainforests of the Northern Andes with 44,028 ha (10.39%) and the North Andean high montane evergreen forest with 35,071 ha (8.28%); while in the inter Andean valleys there is North Andean montane shrubland land covering 36,641 ha (8.65%) and inter Andean dry shrub land extending to 29,065 ha (6.86%). Finally, in the high mountain areas the high montane and montane grasslands predominate with coverage of 44,326 ha (10.46%) (*Figure 2*).

Among the 17 ecological systems in the district eight are forest formations, three are shrublandsshrub lands and six are grasslands. The parish of Checa has 11 of the 17 ecosystems, El Quinche, Pifo and Yaruquí have 10, Lloa, Píntag, Nono and San José de Minas have 9, Atahualpa has 8, and Puellaro has 7.

There are large remnants of rainforests in 17 of the 33 rural parishes in the district. The largest number of rainforest hectares is found in Lloa (38,622 ha), followed by Nanegal, Pacto, Nono, San José de Minas, Nanegalito and Calacalí with about 5,000 ha each.

Piedmont rainforests of the northern Andes are found only in Pacto (7,200 ha) and in small fragments in Gualea (55 ha). In general dry forests are restricted to ten parishes covering smaller areas up to 350 hectares.

ShrublandsShrubs, both wet and dry, are widely distributed in 30 rural parishes, except Pacto, Nanegalito and Gualea. The parishes with a greater amount of shrubland are Píntag (11,481 ha), San Antonio (8,442 ha), Pifo (6,512 ha), Calacalí (6.123 ha) and Calderon (4,224 ha).

Furthermore, grasslands are found in 22 rural parishes, of which Píntag (21,255 ha) and Pifo (10,970 ha) possess the highest number of hectares.


a


b


c

Photo: Anaís Córdova-Páez

Photo: Max Araujo

According to the NatureServe study, frond in natural regeneration includes secondary forest, scrub in regeneration and cork trees and shrubland. Accordingly, only nine of the 33 rural parishes of the MDQ have vegetation with natural regeneration over large areas. The largest areas of natural regeneration are found in the parishes of the Pacto (14,795 ha), Nanegal (7,521 ha) and Gualea (5,037 ha).

In most of the aforementioned parishes there are considerable areas of both secondary forest and scrub in regeneration (*Map 5*). This is important in terms of conservation, as these processes respond to a natural succession that, if it were not interrupted by anthropogenic processes, would contribute to the restoration and connectivity of fragmented ecosystems like piedmont rainforests.

With regard to the presence of eucalyptus, pine and cypress forests, the areas of these are variable in 33 rural parishes, except in Pacto, Gualea and Nanegal, where plantations of exotic species are not recorded. The parishes with more extensive forests of eucalyptus, pine and cypress are Píntag with 1,190 ha, Conocoto with 561 ha, and Pifo with 512 ha.

Congeliturbate and edapho-xerophilous vegetation covers a surface of 48 ha (0.01%) and is located on the crests of the Pichincha, Sincholagua and Atacazo hills. Conservation of this vegetation is high priority as it is constantly threatened by fires. Meanwhile, the piedmont rainforests of the northern Andes, with 6,334 ha (1.50%), which are located in the area at the western end of the district within the area called Chocó and considered to have a high number of endemic birds and plant species , are seriously threatened by deforestation and the establishment of monocultures such as palm trees.

In addition, the High Andean wetlands, where there is a presence of mossy plants requiring soil

a) Cangahua outcrops, b) Natural pasture; C) Paramo moorland; d) Rumipamba Ravine; e) Cork in the humid montane forest; f) River Chiche canyon. *Photos: Secretary of the Environment.*

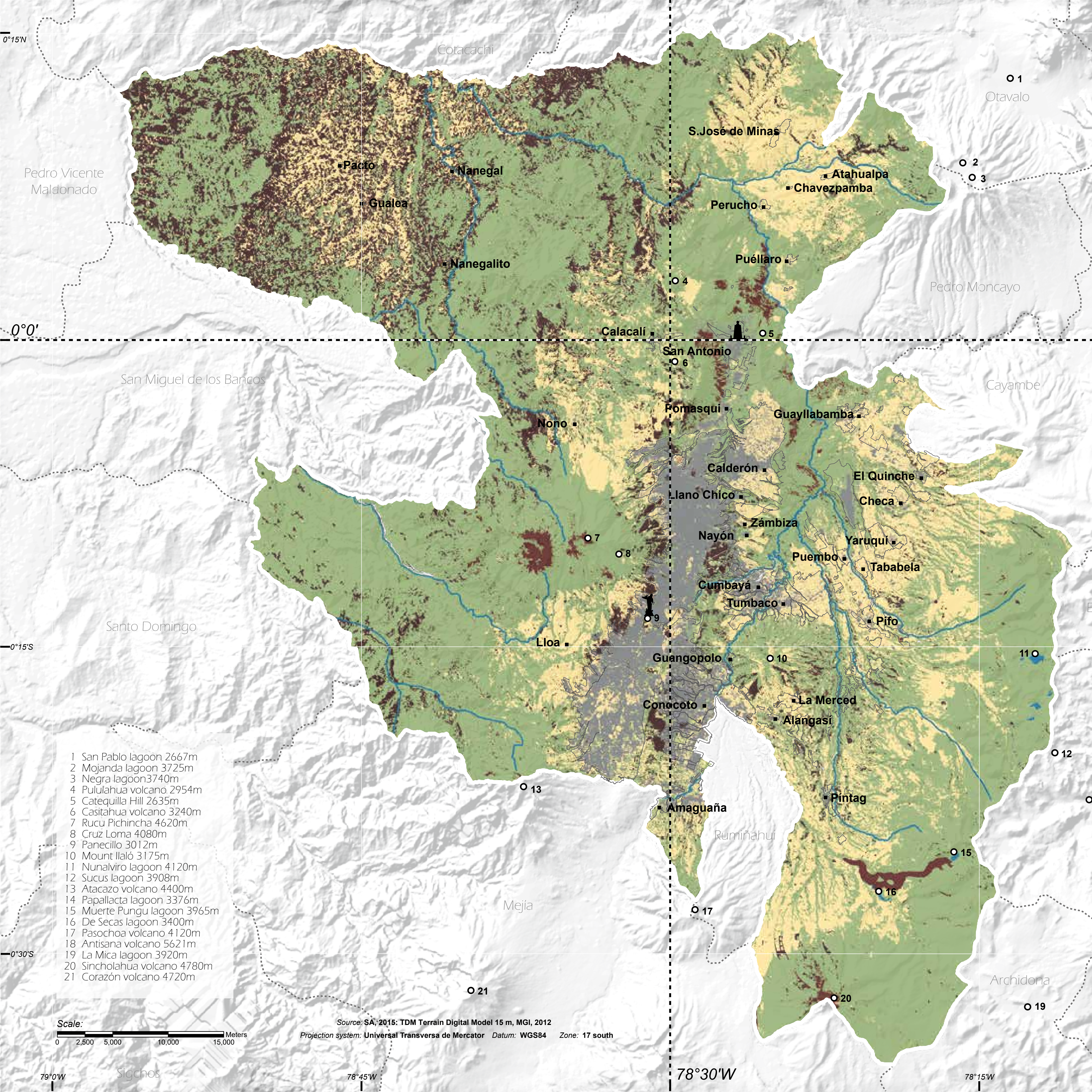
to form marshy vegetation, have an area of 254 ha (0.06%) and are located in the highlands near the moors. The principal threats to this vegetation are from grazing cattle, the advance of the agricultural frontier, and the constant fires occurring in the moors. The inter Andean dry forests face a similar situation with 648 ha (0.15%), which are relegated to small areas in San Antonio, Guayllabamba, Calderón and Puéllaro, affected by cutting and burning for urban and agricultural expansion (*Maps 5, 6 and 7*).

Photo: Anaís Córdova-Páez

Photo: Anaís Córdova-Páez

g) Water system; h) Moss/Marsh paramo moorland; i) Andean crop system; j) Lake system; k) Production system. ***Photos: Secretary of the Environment***


Photo: Germán Toaza
Montane forest, El Cedral


0°15'N
Cotacachi
Otavalo
Pedro Vicente Maldonado
Pacto
Nanegal
Gualea
Nanegalito
S.José de Minas
Atahualpa
Chavezpamba
Perucho
Puéllaro
Pedro Moncayo
0°0'
Calacalí
San Antonio
San Miguel de los Bancos
Cayambe
Pomasqui
Guayllabamba
Nono
Calderón
El Quinche
Llano Chico
Checa
Zámbiza
Nayón
Yaruquí
Puembo
Tababela
Cumbayá
Tumbaco
Pifo
Santo Domingo
Lloa
0°15'S
Guangopolo
Conocoto
La Merced
Alangasí
Amaguaña
Pintag
Rumiñahui
Mejía
0°30'S
Archidona
1 San Pablo lagoon 2667m
2 Mojanda lagoon 3725m
3 Negra lagoon3740m
4 Pululahua volcano 2954m
5 Catequilla Hill 2635m
6 Casitahua volcano 3240m
7 Rucu Pichincha 4620m
8 Cruz Loma 4080m
9 Panecillo 3012m
10 Mount Ilaló 3175m
11 Nunalviro lagoon 4120m
12 Sucus lagoon 3908m
13 Atacazo volcano 4400m
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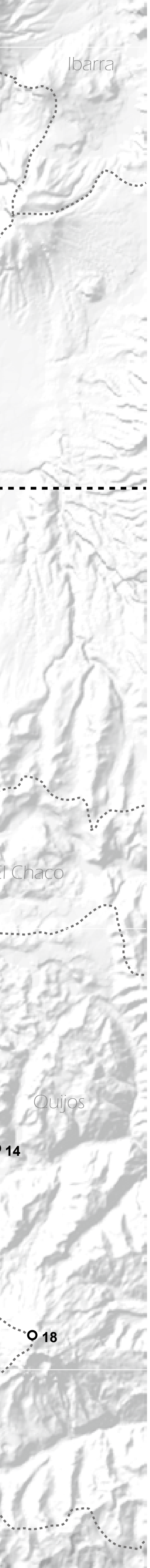
15 Muerte Pungu lagoon 3965m
16 De Secas lagoon 3400m
17 Pasochoa volcano 4120m
18 Antisana volcano 5621m
19 La Mica lagoon 3920m
20 Sincholahua volcano 4780m
21 Corazón volcano 4720m
Scale:
Meters
0 2,500 5,000 10,000 15,000
Source: SA, 2015: TDM Terrain Digital Model 15 m, MGI, 2012
Projection system: Universal Transversa de Mercator Datum: WGS84 Zone: 17 south
79°0'W
78°45'W
78°30'W
78°15'W
Sigchos

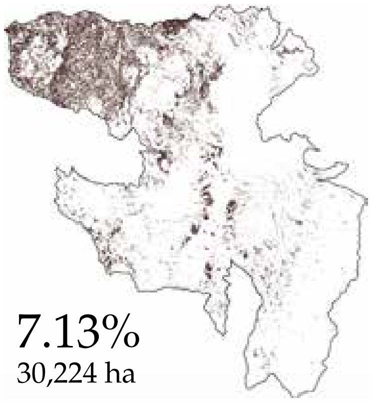


5 Map
Vegetation cover level I in the MDQ

1 Natural vegetation

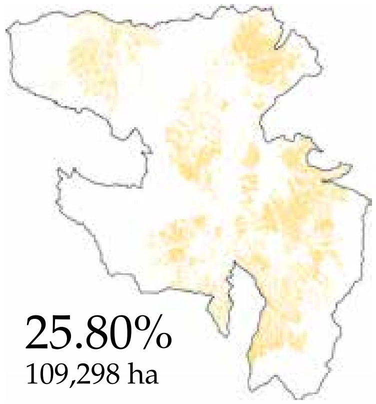
54.48%
230,811 ha

2 Forests and semi-natural areas

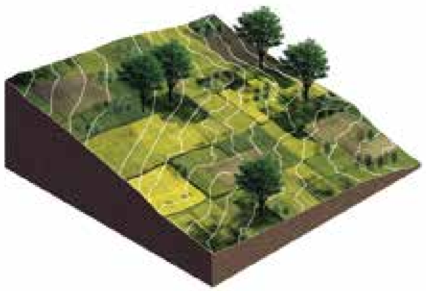


7.13%
30,224 ha

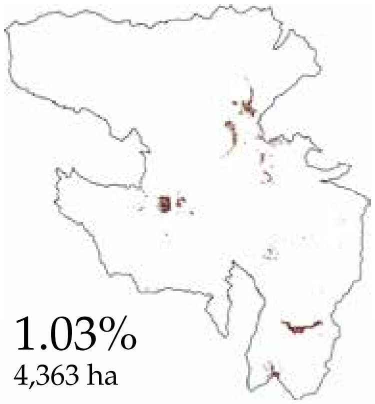
3 Cultivated areas



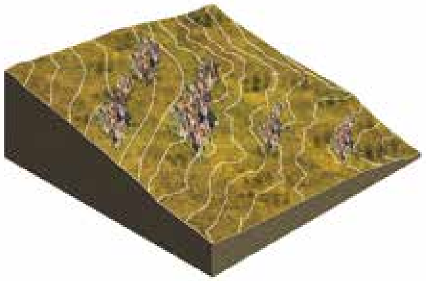
25.80%
109,298 ha



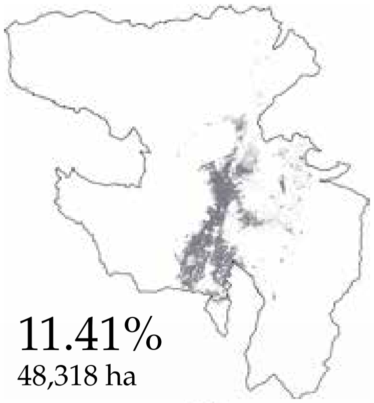
4 Open spaces



1.03%
4,363 ha

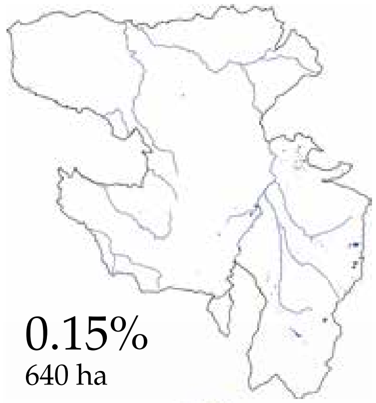


5 Artificial areas



11.41%
48,318 ha

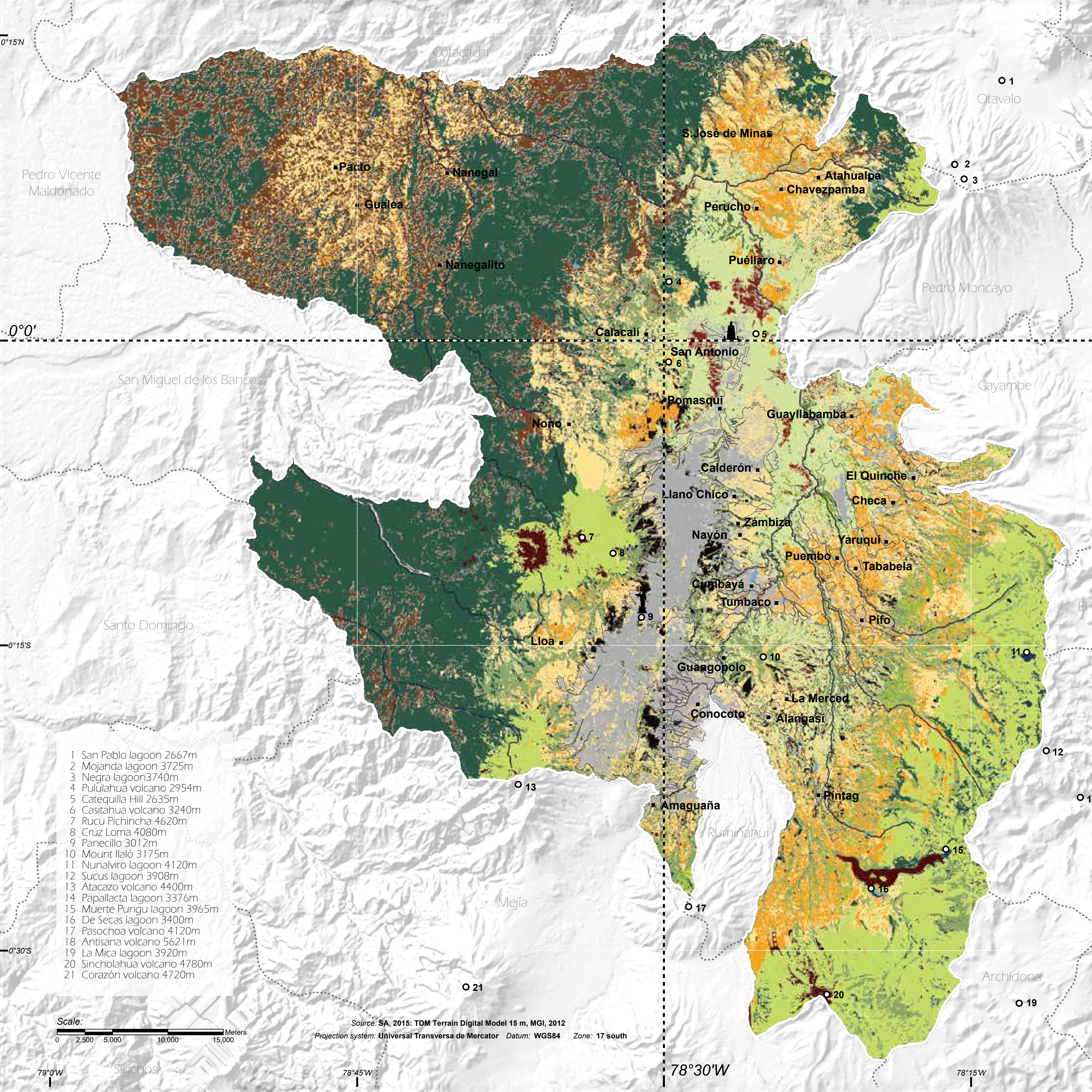
6 Water bodies



0.15%
640 ha

Legend

- Natural vegetation
- Forests and semi-natural areas
- Cultivated areas
- Open spaces
- Artificial areas
- Water bodies



0°15'N
Cotacachi
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0°0'
Calacalí
San Antonio
San Miguel de los Bancos
Pomasqui
Guayllabamba
Cayambe
Nono
Calderón
El Quinche
Llano Chico
Checa
Zámbiza
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0°15'S
Guangopolo
La Merced
Conocoto
Alangasí
Amaguaña
Pintag
Rumiñahui
Mejía
Archidona
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Sigchos
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3 Negra lagoon3740m
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5 Catequilla Hill 2635m
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11 Nunalviro lagoon 4120m
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13 Atacazo volcano 4400m
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18 Antisana volcano 5621m
19 La Mica lagoon 3920m
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Scale:
Meters
0 2,500 5,000 10,000 15,000
Source: SA, 2015: TDM Terrain Digital Model 15 m, MGI, 2012
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79°0'W
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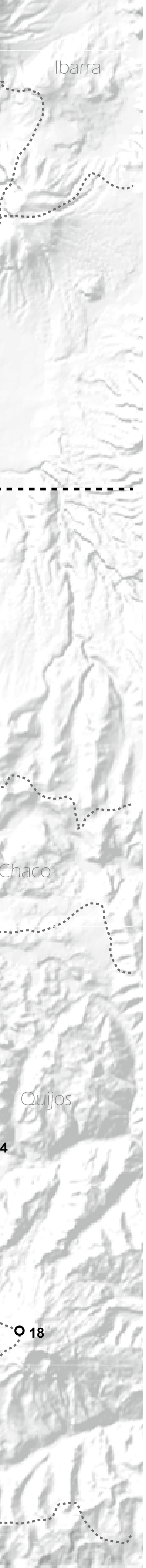
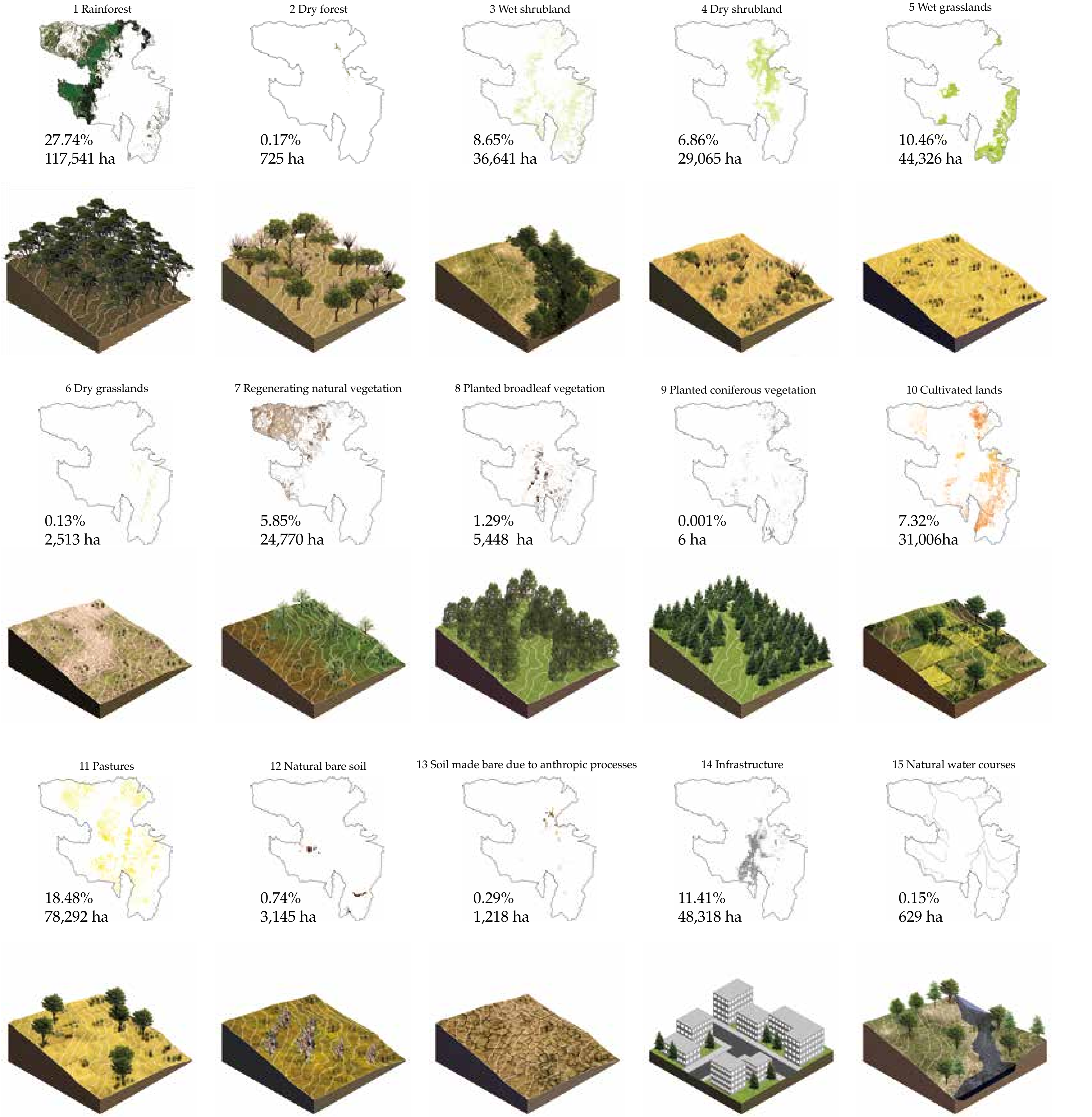
78°30'W
78°15'W



6 Map

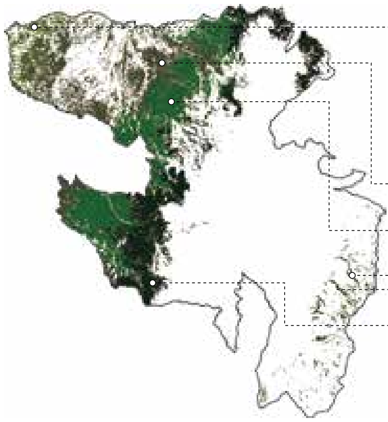
Vegetation Cover level II in the MDQ



Legend

- Rainforest
- Dry forest
- Wet shrubland
- Dry shrubland
- Wet grasslands
- Dry grasslands
- Regenerating natural vegetation
- Planted broadleaf vegetation
- Planted coniferous vegetation
- Cultivated lands
- Pastures
- Natural bare soil
- Soil made bare due to anthropic processes
- Infrastructure
- Natural water courses

7 Map
Vegetation Cover level III in the MDQ

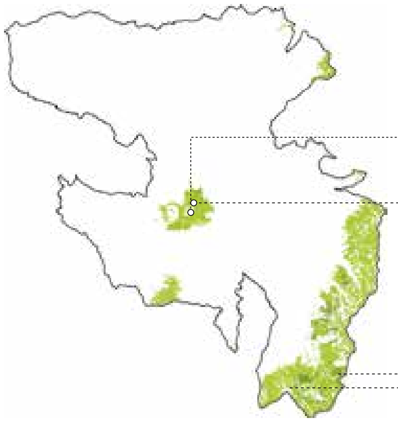


1 Rainforest

- 6,334 ha / 1.50% ● Piedmont rainforests in the northern Andes
- 28,283 ha / 6.68% ● Seasonal evergreen low montane forests in the northern Andes
- 44,028 ha / 10.39% ● Montane rainforests in the northern Andes
- 3,681 ha / 0.87% ● Low forests and high Andean montane shrubland
- 35,071 ha / 8.28% ● High montane evergreen north Andean forests
- 144 ha / 0.03% ● High montane north Andean polylepis forests

2 Dry forests

- 648 ha / 0.15% ● Inter Andean dry forest
- 77 ha / 0.02% ● Montane level xerophytic coastal/riverside vegetation



5 Wet grasslands

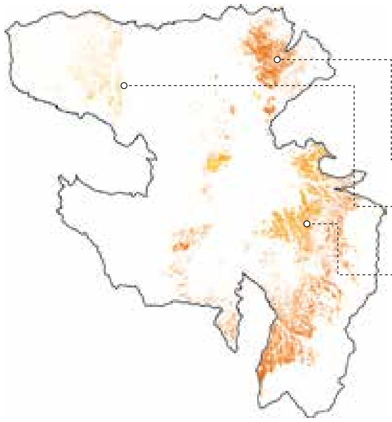
- 38,007 ha / 8.97% ● High montane grasslands and montane moors
- 6,016 ha / 1.42% ● High montane edapho-xerophilous grasslands
- 48 ha / 0.01% ● Congeliturbate and edapho-xerophilous
- 254 ha / 0.06% ● sublevel paramo vegetation

6 Dry grasslands

- 546 ha / 0.13% ● Saxicola inter Andean montane vegetation of the northern Andes
- 1,968 ha / 0.46% ● Montane grasslands

9 Planted coniferous vegetation

- 6 ha / 0.001% ● Pines



10 Cultivated lands

- 16,903 ha / 3.99% ● Short cycle crops
- 10,179 ha / 2% ● Semi-permanent and permanent crops
- 3,925 ha / 0.93% ● Greenhouse crops

13 Soil made bare due to anthropic processes

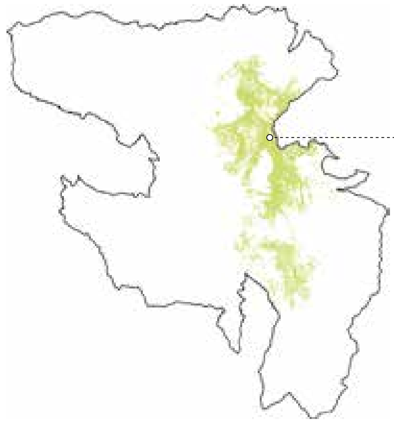
- 754 ha / 0.18% ● Quarries
- 1,218 ha / 0.29% ● Eroded soil

14 Infrastructure

- 48,318 ha / 11.41% ● Buildings

3 Wet shrubland

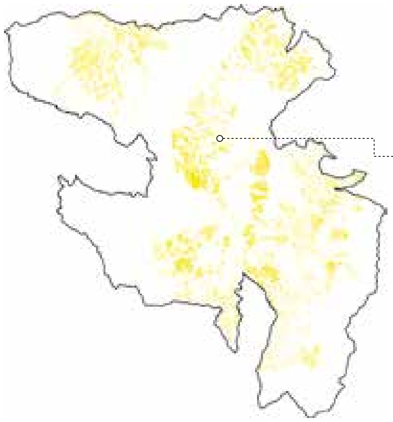
4 Dry shrubland



7 Regenerating natural vegetation

8 Planted broadleaf vegetation

11 Pastures



12 Natural bare soil

15 Natural water courses

16 Artificial water course

BIOLOGICAL DIVERSITY

The MDQ has a high biodiversity resulting from its heterogeneity of landscapes and climate. A wide variety of ecosystems can also be found ranging from permanent glaciers, through wet and dry moorland, montane forests, dry inter Andean valleys to evergreen piedmont forest, where there is high concentration of species of wild flora and fauna, comparable to the levels of diversity of the tropical Amazonian zones (MECN, 2010).

Large blocks of native vegetation located from the foothills of Pichincha volcano to the Mojanda lakes are the areas with the highest concentration of biodiversity and endemism. In this strip of land there are three different assemblies of animal and plant species found at distances of less than 3km apart. Some of these areas have suffered less anthropic alterations due to being located in areas with steep slopes or having protected status.

The plant formations containing higher proportions of endemic species are the cloud forests, the high and low montane forests of the western slopes of the Andes and the montane dry scrub in the inter Andean valley (Valencia, Cerón & Palacios, 2000).

Subtropical and tropical areas are also home to great biodiversity and are located within the territory of the MDQ, for example the transition environments between the Andean region and el Chocó. Diversity decreases significantly in the dry inter Andean valleys and the paramo, influenced by the high altitude and the climatic conditions of low precipitation and temperatures.

There are other areas of great biological importance in the MDQ such as the forests of the parish of San José de Minas, the forests close to Maquipucuna, Marianitas, Porvenir and around Bellavista and near Tandayapa and Chiquilpe, the forests between Chiriboga and Zaragoza, the lower area


a


b


c

Emblematic species of Quito; a) Sparrow; b) Cuico; c) Beetle; d) Quito blackberry; e) Pacay; f) Andean fox ▪ Photos: Finding species

d

e

f

of Pachijal, the dry forests of the equatorial zone and Guayallabamba canyon, and the areas near Saguangal.

The Maquipucuna Reserve, consisting of temperate and subtropical ecosystems, is one of the largest refuges of endemic wild flora and fauna and forms the western boundary of the bio-geographic region of el Chocó. Moreover, the Nueva Esperanza-Guayllabamba dry forest constitutes a unique inter Andean ecosystem, although with little diversity, its remaining vegetation is essential in attracting moisture and as a refuge for many species of wild fauna.

The southwestern district, which contains the parish of Lloa, consists of high Andean ecosystems, the moors and grasslands on the slopes of Guagua Pichincha volcano, and subtropical areas whose forests are of great importance for water regulation.

By contrast, urban areas such as the Guanguiltagua Metropolitan Park, Itchimbía Park and Club Campestre Agua y Montaña exhibit a low diversity of wild species due to the transformation of their original habitats caused by the replacement of native vegetation with exotic species. However, they still retain relict populations of endangered species and are visited by migratory birds.

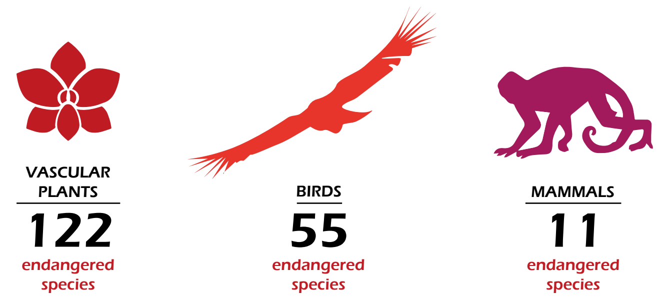
In the MDQ two regions of high endemism can be identified: 1) el Chocó in tropical and piedmont areas under 1,000 meters above sea level and 2) the foothills of the Andes of southern Colombia and northern Ecuador between 1,500 and 3,600 meters above sea level.

"Certain groups of vertebrates (glass frogs, preñadilla catfish, hummingbirds) and epiphytes (orchids, mosses, ferns) achieve a higher degree of diversification in the foothills of the mountains, which are well represented in the territory of the MDQ" (MECN, 2010).

Ecosystems with higher concentrations of threatened species are high montane forest and piedmont forest (*Infographic 2*).

There is no other capital and metropolitan district in the world with such a gala of great biological wealth in its territory as Quito. The MDQ includes the low

Infographic 2. Ecosystems with endangered species



subtropical regions of Nanegal, Pacto and Gualea, areas of high Andean paramo around the Pichincha volcano, regions of Andean forest in Nanegalito, Nono and Lloa, and the temperate valleys and dry forests of Cumbaya, Tumbaco, Puembo, Pifo, Guayllabamba and San Antonio de Pichincha (Carrion, J.M. 2011).

As for the District's richness in flora and fauna, we can highlight:

- 18,018 varieties of plants.
- 112 species of mammals representing 28.5% of those registered in Ecuador. Among the species indicating good quality ecosystems we can cite the spectacled bear (*Tremarctos ornatus*), the tamarin (*white-fronted capuchin aequatorialis*), the mantled howler (*Alouatta palliata*) and the dwarf deer (*Pudu mephistophiles*); all of these are exposed to some level of threat.
- In the District there are 542 bird species representing 32% of all the birds registered in Ecuador (1,660 species), among which we can highlight the Black-breasted puffleg (*Eriocnemis nigrivestis*), the emblematic bird of the District, and the Andean condor (*Vultur gryphus*), a bird of importance and national identity, both of these falling within the critically endangered species category.

Flora in the MDQ

Thanks to the collections, field research, systematization and analysis of bibliographic information performed by the Ecuadorian Museum of Natural Sciences (MECN, 2010), we have a list of 2,330 species of vascular plants, of which 11% (254) of this total are registered as endemic species and 5% (122) fall into the endangered species category (Valencia R., 2000) (*Figure 2*).

Photo: Luis Baquero

Cyrtochilum macranthum

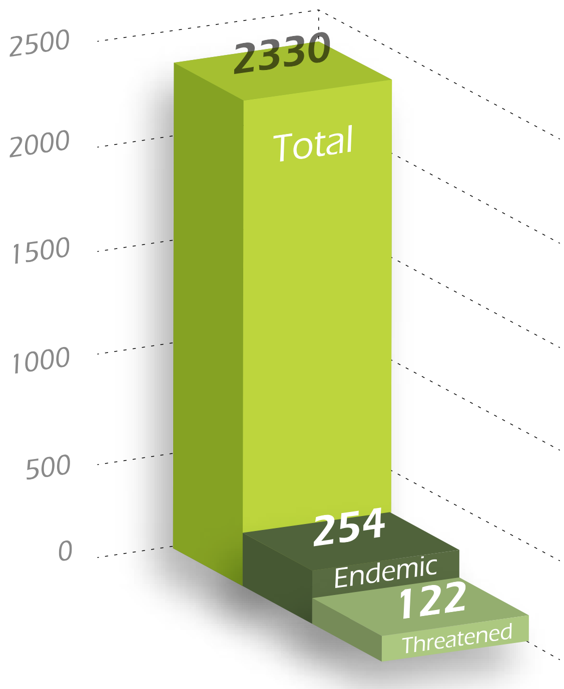
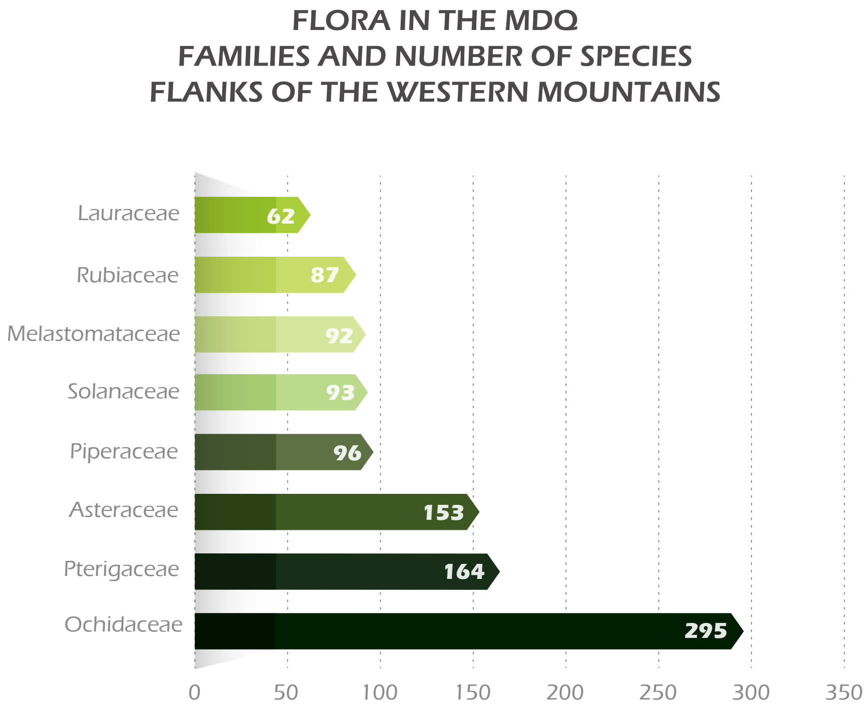


Figure 2. Number of vascular plant species in the MDQ

Source: (MECN, 2010, op. cit.)
This list includes subjects undetermined at species level due to a lack of fertile samples preventing their complete identification; hence, the number of species may vary.
The number of registered species constitutes 14% of the total number of vascular plants known in Ecuador (17,058), according to the *Catalogue of Vascular plants in Ecuador* (Ulloa and Neil, 2004).
The endangered species include: Critical danger (CR), Endangered (EN) and Vulnerable (VU), according to Valencia et al, 2000.



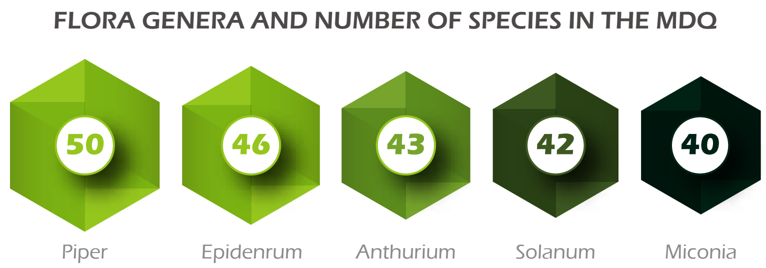


Figure 3. Flora in the MDQ, families and genera
Source: (MECN, 2010, op. cit.)
Several families and genera of the Orchidaceae, Cyperaceae, Piperaceae and Cucurbitaceae families are classified as 'rare'.

The flanks of the western mountains are home to great floristic wealth, unique to the el Chocó bio-geographic region. Several families and genera inhabit the cloud forests, the most important of which are presented in *Figure 3*.

The *Orchidaceae* family is the most common with 295 identified species, and less common but no less important is the *Lauraceae* family of avocado and laurel plants. Moreover, other relevant genera are the Piper (*Piperaceae* family) and *Epidendrum* (*Orchidaceae* family).

The district also possesses an abundance of epiphytes from the *Orchidaceae* families representing 7% of the orchids in the country: *BroMeliaceae*, *Araceae*, *Piperaceae*, *Ericaceae*, *Gesneriaceae*, *Pteridophyta* (ferns) and *Briophytas* (mosses), *Clusia alata* (*Clusiaceae*) and *Myrcianthes rhopaloides* (*Myrtaceae*), *Cyathea caracasana* (*Cyatheaceae*), *Hyeronima macrocarpa* (*Euphorbiaceae*), *Nectandra membranacea* (Lauraceae), *Guarea kunthiana* (*Meliaceae*), and *Pitcairnia sodiroi*. These species are recorded as 'common species' at various sites on the western flank of the Pichincha volcano.

The sites with the largest wealth of species are located in the cloud forests, including: Las Palmas (311), Pahuma (256) and Cambugán (215). Similarly, located

Photo: Max Araujo

Brugmansia

in the evergreen piedmont forests are the Mashpi (197) and Las Tolas (185) reserves. Furthermore, the dry valley of Guayllabamba (133), due to its characteristic ecosystems, has a discreet wealth of xeric site species (*Map 8*).

Fauna in the MDQ

Mammals

In the MDQ 112 species from 28 families and 11 orders of fauna are registered, representing 29% of all mammals in Ecuador. This number includes the olinguito, which was discovered in 2013 and is the first new carnivore species identified in the Western Hemisphere in 35 years (Mundo Magazine, 2013). The most abundant groups are rodents with 38 species, bats with 35, and carnivores with 14. Among the 13 species endemic to Ecuador, ten belong to the order Rodentia: the aquatic rat (*Anotomys leander*) the Pichincha Oldfield mouse (*Thomasomys vulcani*) and the Andean mouse (*Thomasomys ucucha*), and a species of the order *Chiroptera*, the tube-lipped nectar bat (*Anoura fistulata*) (*Figure 4*).

Table 3 shows the 11 species of mammals considered to be in some category of threat. The species known as 'howler monkey' and 'Ecuadorian capuchin' are at greatest threat.

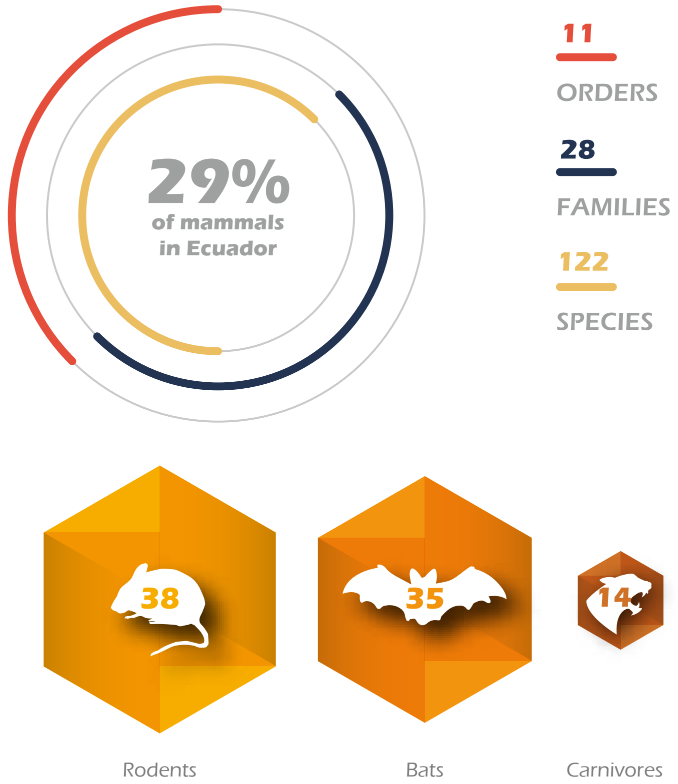
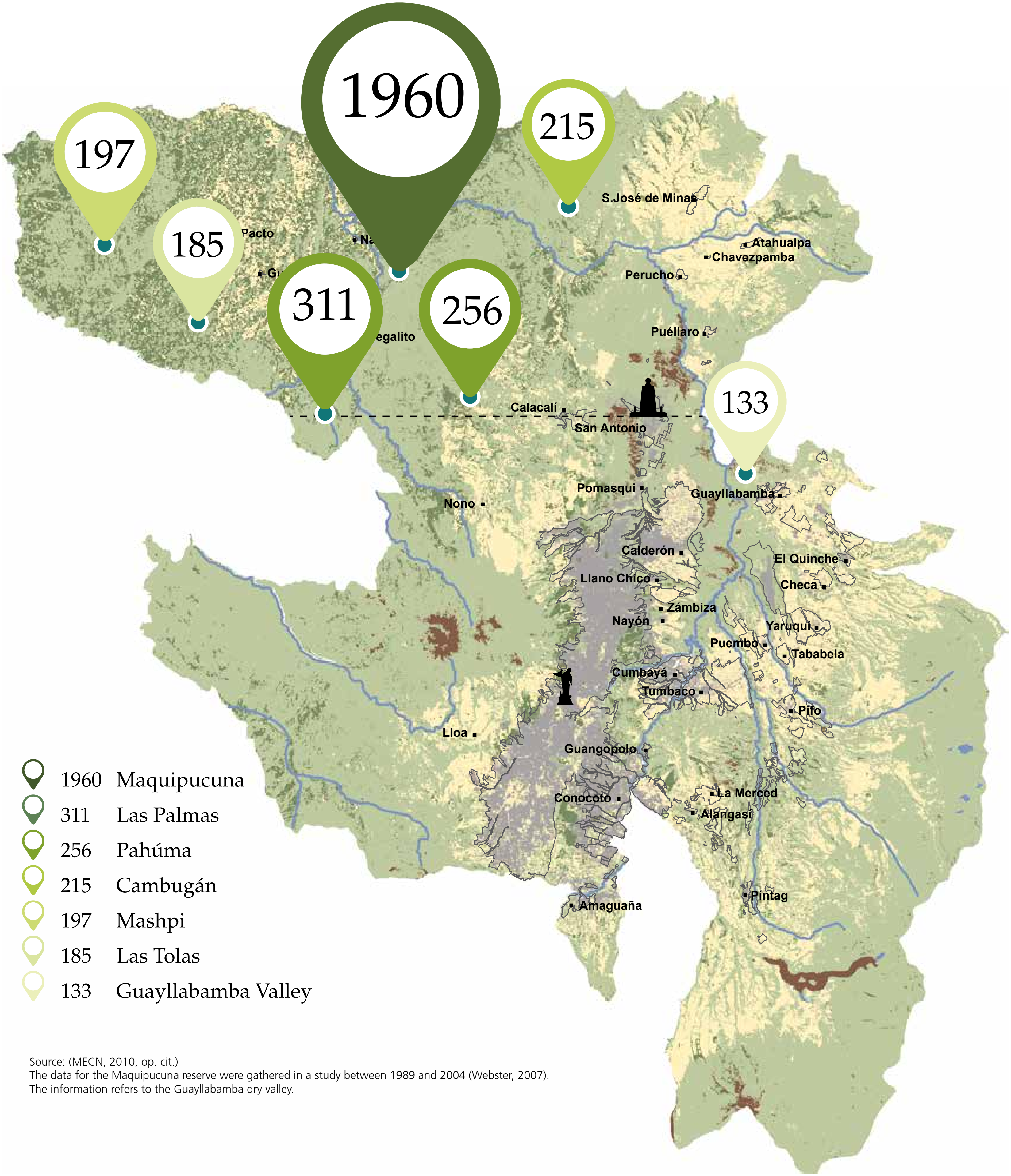


Figure 4. Species, orders and families of identified mammals in the MDQ

Source: (MECN, 2010, op. cit.)
Data registered in 2010.
Among these species, eight have new information regarding their taxonomic definition: foxes in the genera Didelphis and Marmosops, shrew (*Cryptotis*), *Sturnira* bat, rat (*Melanomys phaeopus*), Andean mouse (*Akodon sp.*), *Oligoryzomys sp.* and *Nephelomys Moerex*.
One species presents a new distribution in the tropical forests of the MDQ: the red bat (*Lasiurus Blossevilii*) which was previously registered in the southwest forests of the Ecuadorian coast.

8 Map

Number of species per reserve in the MDQ



Source: (MECN, 2010, op. cit.)
The data for the Maquipucuna reserve were gathered in a study between 1989 and 2004 (Webster, 2007).
The information refers to the Guayllabamba dry valley.

Table 3. Mammal species in the MDQ and their threat categories

Species	Threat category
Ecuadorian Capuchin *Cebus albifrons aequatorialis*	CR
Choco broad-nosed bat *Platyrrhiunus chocoensis*	EN
Ecuadorian grass mouse *Akodon latebricloa*	VU
Aquatic rat *Anotomys leander*	VU
Andean long-tailed mouse *Thomasomy ucucha*	VU
Pacarana *Dinomys branickii*	VU
Spectacled bear *Tremarctos ornatus*	VU
Oncilla *Leopardus tigrinus*	VU
Neotropical otter *Lontra Longicaudis*	VU
Little red brocket *Mazama rufina*	VU
Northern pudu *Pudu mephistophiles*	VU

Source: MECN 2010

EN :Endangered CR :Critical danger VU : Vulnerable

In terms of altitudinal level, of the 134 species of mammals registered for all the northwestern tropical floor, 61 (46%) are found in the tropical forests of the MDQ, which represent 55% of all species recorded in the MDQ (MECN, 2010). Among the species indicating the good state of conservation of ecosystems are the spectacled bear (*Tremarctos ornatus*), the puma (*Puma concolor*), the brocket (*Mazama rufina*), the Ecuadorian capuchin (*Cebus albifrons aequatorialis*) and some small mammals such as the white-lined bat (*Platyrrhinus nigellus*) and the Andean mouse (*Nephelomys moerex*).

The forest in the Verdecocha Reserve deserves special attention due to the fact that eight species indicating the good condition of the forest reside there, four endemic species and six species in the highest risk category of the International Union for Conservation of Nature (IUCN).

Elsewhere, the sector of La Virgen in Nono is home to nine endemic species and six endangered species. Other sites of importance are those that are not protected such as the sectors of Zaragoza and La Unión, home to two endemic species, five indicator species and five in some degree of threat; and the sector of La Victoria, which has five indicator species, three endemic species and six under some degree of threat.


Photo: Metropolitan News Agency

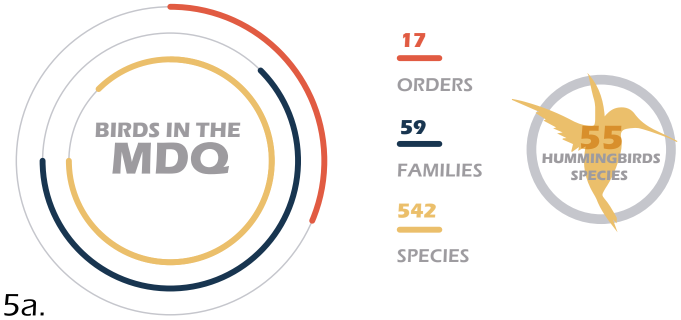
Spectacled Bear , Maquipucuna reserve

Birds

Ecuador is the country of birds, with 1,660 species. In its territory, covering 256,370 km2, are concentrated 17% of the world's total bird species. As such, the country ranks fourth in the world, behind Colombia, Peru and Brazil, neighboring countries with territories much greater than Ecuador. Therefore, when establishing a relationship between the size of the country and the number of bird species, Ecuador ranks first by a wide margin. Definitively, Ecuador is the country of birds and Quito is the capital of the country of birds (Carrión, J.M., 2011).

At an altitudinal gradient extending from 500 to 4,780 meters above sea level, the MDQ presents several ecological formations that are home to a large population of birds – it is estimated there are 542 species, including 64 endemic at the regional level and one that is exclusive to Quito. This supreme ornithological wealth is colorfully exemplified by hummingbirds, the natural emblem of Quito of which there are 55 different species in the district. This is the land of hummingbirds (Carrión, J.M., 2011) (*Infographic 3*).

There are 542 species from 59 families and 17 orders registered in the MDQ (MECN, 2010), demonstrating high diversity. Despite constant anthropic pressure and the state of fragmentation of ecosystems, virtually all groups are present. The most diverse orders are the *Passeriformes*, the *Tyrannidae* (flycatchers), *Thraupidae* (tanagers), *Trochilidae* (hummingbirds) and *Furnariidae* (ovenbirds, woodcreepers) (*Figure 5a*).



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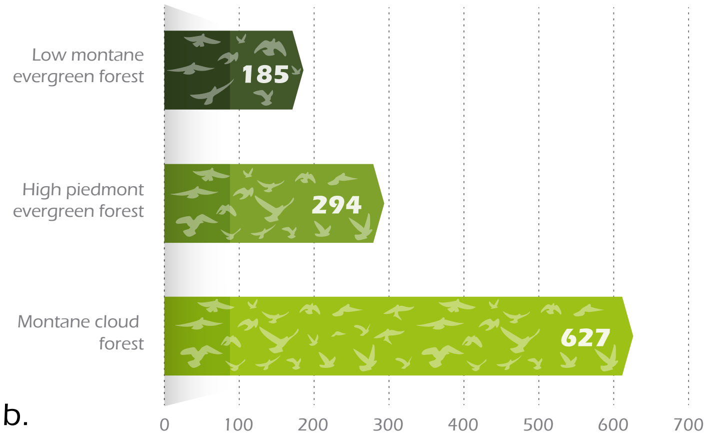


5b.

Figure 5. Identified birds in the MDQ

Source: (MECN, 2010, op. cit.)
The data correspond to a study performed by the MECN on 21,410 records in 21 sites in the MDQ. The identified species in this study represent 43% of all the registered species in the MDQ.

Photo: Murray Cooper

Black-breasted puffleg (*Eriocnemis nigrivestis*)

Table 5. Bird species in the MDQ

	MDQ			Ecuador
	ENDANGERED SPECIES (#)	ENDEMIC SPECIES (#)	TOTAL SPECIES	REGISTERED SPECIES (#)
SPECIES (#)	55	61	519	1616
Representativeness at local level (%)	10.6	11.7	100	n/a
Representativeness at national level			34	100

Among the endangered species are: the Black-breasted Puffleg (*Eriocnemis nigrivestis*), the Andean Condor (*Vultur gryphus*), the Brown Wood Rail (*Aramides wolfi*), and the Banded Ground Cuckoo (*Neomorphus radiolosus*), which have been placed in the critical danger category.

Photo: Murray Cooper

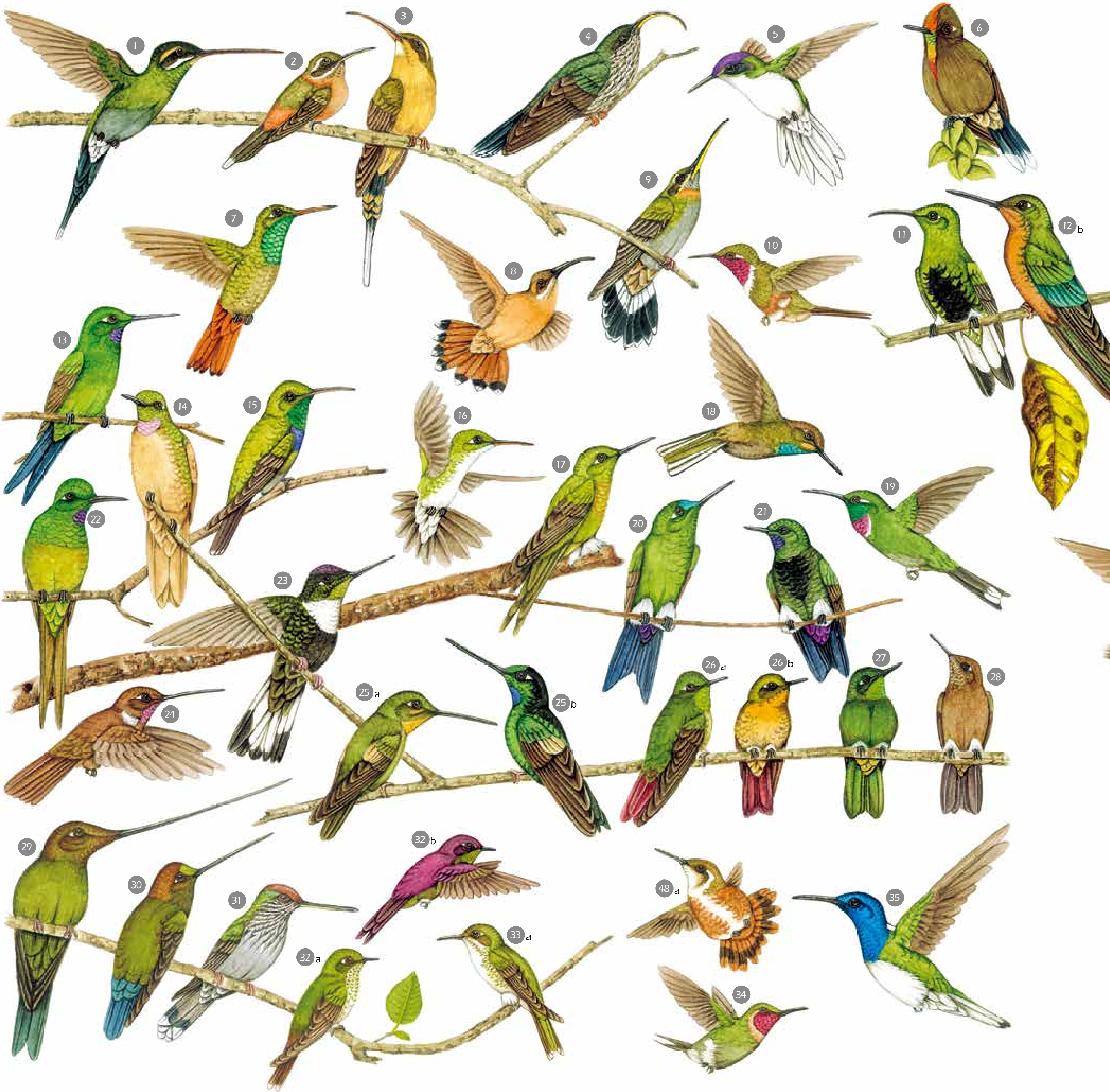
Toucan barbet (*Semnornis ramphastinus*).

Due to the great diversity of birds that the MDQ possesses some ecosystems and habitats form part of a global conservation initiative identifying the 'Important Bird Areas'. The IBAs are sites of global priority for the conservation of wild bird populations in which activities such as the protection of natural areas, sustainable practices, environmental education, and nature tourism with an emphasis on bird watching and research are performed.

In this context, the IBAs found in the MDQ are as follows: Maquipucuna-river, Guayllabamba, Mashpi-Pachijal and Pacto, the largest IBA in the MDQ, Mindo and the western slopes of the Pichincha volcano. Other smaller IBAs in the district are: the Pasochoa Wildlife Refuge, Atacazo volcano, the valley of Guayllabamba and Cayambe Coca Ecological Reserve (Santander, Tatiana, undated).

Due to the geographic, topographic and climatic characteristics the MDQ possesses unique habitats and ecosystems harboring a great diversity of birds, a large percentage of which are endemic and endangered (*Table 5*). These birds are distributed throughout all the ecosystems from 500 to 4,500 m above sea level (see *Figure 5b*).

There has been bird watching tourism in the northwest of the MDQ for more than 30 years, and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Infographic 3. Hummingbird species in the MDQ

Illustration: Juan Manuel Carrión, 2011

1. White-whiskered hermit / *Phaethornis yaruqui*
2. Ecuadorian hermit / *Phaethornis baroni*
3. Tawny-bellied hermit / *Phaethornis syrmatophorus*
4. White-tipped sicklebill / *Eutoxeres aquila*
5. Purple-crowned fairy / *Heliothryx barroti*
6. Rainbow-bearded thornbill / *Chalcostigma herrani* (male)
7. Rufous-tailed hummingbird / *Amazilia tzacatl* (male)
8. Bronzy hermit / *Glaucis aenea*
9. Band-tailed barbthroat / *Threnetes ruckeri*
10. Purple-throated woodstar / *Calliphlox mitchelli* (male)
11. Mountain velvetbreast / *Lafresnaya lafresnayi* (male)
12. Great sapphirewing / *Pterophanes cyanopterus* (a: male, b: female)
13. Green-crowned brilliant / *Heliodoxa jacula* (male)
14. Fawn-breasted brilliant / *Heliodoxa rubinoides* (male)
15. Purple-chested hummingbird / *Amazilia rosenbergi* (male)
16. Andean emerald / *Amazilia franciae* (male)
17. Golden-breasted puffleg / *Eriocnemis* mosquera
18. White-tailed hillstar / *Urochroa bougueri*
19. Purple-bibbed whitetip / *Urosticte benjamini* (male)
20. Sapphire-vented puffleg / *Eriocnemis luciani*
21. Black-breasted puffleg / *Eriocnemis nigrivestis* (male)
22. Empress brilliant / *Heliodoxa imperatrix* (male)
23. Collared inca / *Coeligena torquata* (male)
24. Brown inca / *Coeligena wilsoni*
25. Buff-winged starfrontlet / *Coeligena lutetiae* (a: female, b: male)
26. Tyrian metaltail / *Metallura tyrianthina* (a: male, b: female)
27. Viridian metaltail / *Metallura williami* (male)
28. Hoary puffleg / *Haplophaedia lugens*
29. Sword-billed hummingbird / *Ensifera ensifera* (male)
30. Green-fronted lancebill / *Doryfera ludoviciae*
31. Tooth-billed hummingbird / *Androdon aequatorialis*
32. Purple-backed thornbill / *Ramphomicron microrhyn-chum* (a: female, b: male)
33. Booted racket-tail / *Ocreatus underwoodii* (a: female, b: male)
34. Little woodstar/ *Chaetocercus bombus* (male)
35. White-necked Jacobin / *Florisuga mellivora* (male)
36. Wedge-billed hummingbird / *Schistes geoffroyi* (male)
37. Green-crowned woodnymph / *Thalurania fannyi* (a: male, b: female)
38. Violet-tailed sylph / *Aglaiocercus coelestis* (a: male, b: female)
39. Purple-collared woodstar / *Myrtis fanny* (male)
40. Shining sunbeam / *Aglaectis cupripennis* (male)
41. Black-tailed trainbearer/ *Lesbia victoriae* (a: male, b: female)
42. Green-tailed trainbearer / *Lesbia nuna* (male)
43. Velvet-purple coronet / *Boissonneaua jardini* (male)
44. Chestnut-breasted coronet / *Boissonneaua matthewsii*
45. Long-tailed sylph / *Aglaiocercus kingi* (male)
46. Speckled hummingbird / *Adelomyia melanogenys*
47. Green thorntail / *Popelairia conversii* (a: male, b: female)
48. White-bellied woodstar / *Chaetocercus mulsant* (a: female, b: male)
49. Gorgeted sunangel / *Heliangelus strophianus* (male)
50. Green violetear / *Colibri thalassinus*
51. Sparkling violetear / *Colibri coruscans*
52. Brown violetear / *Colibri delphinae*
53. Western emerald / *Chlorostilbon melanorhynchus* (a: male, b:female)
54. Ecuadorian hillstar / *Oreotrochilus chimborazo* (male)
55. Giant hummingbird / *Patagona gigas* (male)

Quito is the entrance gateway for birdwatchers and one of the most bio-diverse districts in the world. In this context, in the northwest there are private and community tourism initiatives for observing nature with an emphasis on bird watching.

While the urban sprawl of Quito is centered in the Andean valley, it has easy and fast access to high areas, the paramo and upland forests, as well as subtropical and tropical cloud forests. The latest ornithological inventories for the MDQ indicate that of the 1,660 species of birds in the country, 542 are distributed in the protected areas, private reserves, farms and ravines of Metropolitan Quito (Cruz, G., 2012).

Of these 542 bird species, 61 are endemic (11%) at regional and local level and 30 species (6%) are endangered or nearly endangered globally. Among the species that stand out from this list are the Black-breasted puffleg (*Eriocnemis nigrivestis*), the Andean condor (*Vultur gryphus*), the brown wood rail (*Aramides wolfi*) and the Banded Ground Cuckoo (*Neomorphus radiolosus*), which fall into the Critically Endangered category (see *Table 5*).

Most of the species registered in the MDQ are residents; however, 34 migratory species, of which 28 are boreal migrants, five are southern migrants and one is an inter-tropical migrant have been counted. Most species of migratory birds are small and belong to the *Tyrannidae* (flycatchers), *Parulidae* (warblers) and *Hirundinidae* (Swallows) families.

Some migratory species are of conservational importance as their populations have been declining in recent years, especially due to habitat destruction; however, artificially created wetlands such as the Itchimbía Park are used by migratory species such as *Anas discors*, *Larus atricilla* and *Tringa solitaria*.

Dry forests, due to their ecosystem characteristics, maintain a naturally low diversity of species, for example the dry forest of Guayllabamba (32 species).

The conservation of various forest remnants, especially cloud forests, of which there is a large percentage in the MDQ, is essential, as their importance lies in the environmental services they provide such as water regulation and the capture of carbon dioxide. Subtropical ecosystems have a high diversity of birds, although their forests have been highly fragmented by farming, agricultural and logging activities.

Frog


Lizard

Amphibians and reptiles

The herpetofauna of the MDQ consists of 148 species, 92 amphibians and 53 reptiles. Of the amphibians, 88 of these species are frogs or toads (*Anura*), as well as two salamanders (*Caudata*) and two *Caeciliidae*. There are three new records of reptiles: the Choco Anole (*Anolis chocorum*), the *Anolis lyra* and the *Anolis princeps*.

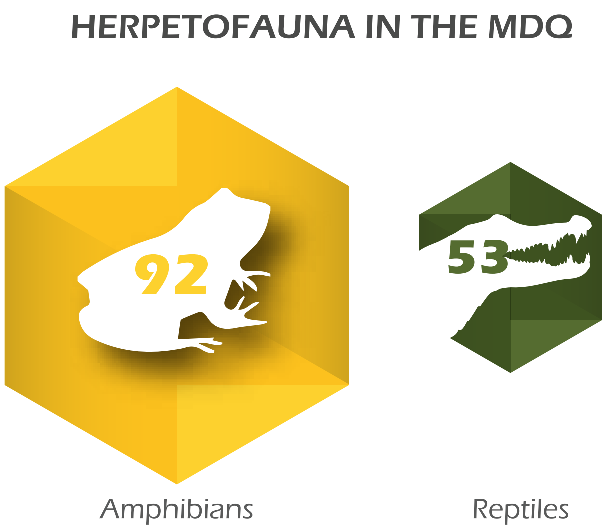
Anurans or tailless amphibians are represented mostly by a wealth of terrestrial frogs (*Strabomantidae*) which constitute more than half of the total diversity of the MDQ's amphibians (50 species) (*Figure 6*).

Glass frogs (*Centrolenidae*) account for a significant diversity with 15 species, more than the protected areas of the lower Amazon and similar to the Cotacachi-Cayapas Reserve in the western Andes of Ecuador. The remaining diversity of Anurans is composed of True toads (*Bufonidae*), Tree frogs (*Hylidae*), Poison dart frogs (*Dendrobatidae*), Marsupial frogs (*Hemiphractidae*) and Southern frogs (*Leptodactylidae*).

Although rare and difficult to observe, the territory of MDQ also houses caudates or amphibians with tails, represented by lungless salamanders (*Plethodontidae*) and *Gymnophiona* or limbless amphibians, the digging *Caeciliidae* and the aquatic *Rhinatrematidae*.

New species and new distributions

In the northwestern forests new species of flora and fauna to science have been found and distribution expansions recorded. “The new species of flora belong to the genera *Myrcianthes*, *Ruagea* and *Talauma*. Three of the four new species of amphibians correspond to the *Pristimantis* genus and one to the *Teratohyla* genus. Also, the reptile *Anolis proboscis* was rediscovered. The distribution range was extended for the Eastern red bat (mammal, *Lasiurus borealis*), for the amphibians *Colomai Pristimantis*, *P.eugeniae*, *Centrolene heloderma* and *Cochranella orejuela*, for the Black-breasted puffleg Hummingbird (*Eriocnemis nigrivestis*), and for macroinvertebrates of the genera *Triaenodes* and *Neoatriplectides*.” (MECN, 2010, opening citation).



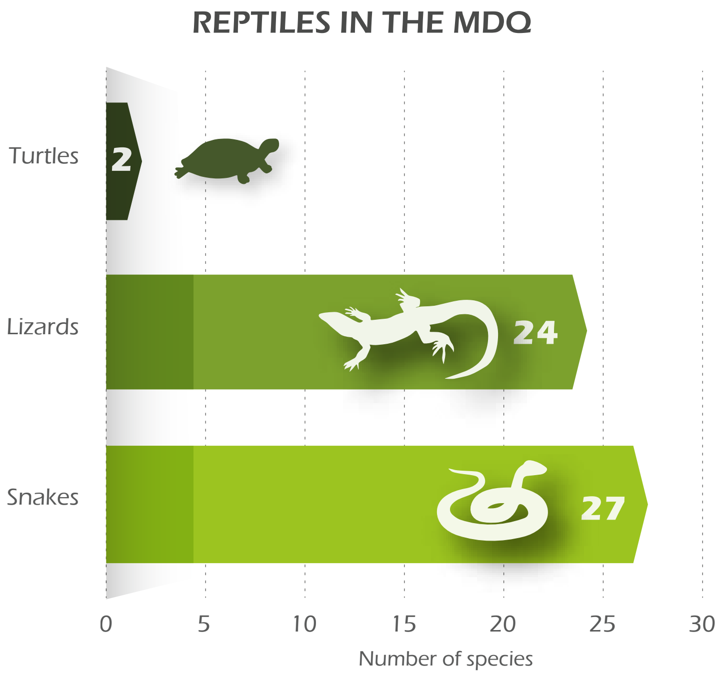


Figure 6. Reptiles in the MDQ

Source: (MECN, 2010, op. cit.)
Note: The orphidians correspond to Snakes (*Serpent*), lizards (*Sauria*) and turtles (*Chelonia*). The snakes broadly consist of the *Colubridae* family, which represents more than a quarter of the total diversity of reptiles registered in the MDQ (18 species). This group includes six species of vipers (*Viperidae*), Coral snakes (*Elapidae*), and Dwarf boas (*Tropidophidae*). The Saurians or lizards include groups that are well-represented by families of spectacled lizards (*Gymnophthalmidae*), iguana lizards (*Polychrotinae*), and fake iguanas.

Note: Data on invertebrates are not included in this document.

Photo: Germán Toasa

Iguana

TERRITORIAL DYNAMICS

Population growth

The population of the MDQ in the year 2010, as indicated by the decennial censuses (*Map 9*), was 2,239,191 inhabitants, while by 2020 it could reach 3,059,097 inhabitants. Of these, approximately 80% live in urban areas and 20% in rural areas.

Similarly, *Map 9* also shows the trend of urban-rural population densification, it being the parishes bordering the south and north of the city (Quitumbe, Turubamba, Guamaní, El Condado, Cochapamba and Carcelén) which have a marked increase in population. However, peri-urban sectors are the fastest growing and mark a trend of city consolidation; these parishes are Calderon and Conocoto.

This rapid population growth will increasingly require and demand new city services and infrastructure, but also a different sense of citizenship and participation to which inhabitants must commit in the face of new habits of consumption and production.

Urban sprawl

Despite intensive planning and municipal regulation, the use and occupation of land has undergone continuous change and accelerated in the last five years, with a tendency to increase the urbanization process in the the valleys of Tumbaco, Chillos and San Antonio, the result of an increasing population; 72% of the MDQ's 2,239,191 inhabitants live in urban areas and 28% in the valleys and rural areas.

A long term aggravating factor of this territorial scenario is climate change or global climate variability, which affects the functioning of the ecosystem and various production systems in their ability to maintain viability, seasonality and growth (SEI, 2013).

The urban sprawl or built-up area has grown exponentially in the past five years with an increased area of 47,340 ha, equivalent to 11.17% of the district, which raises the argument for limited control and regulation of the territory facing new

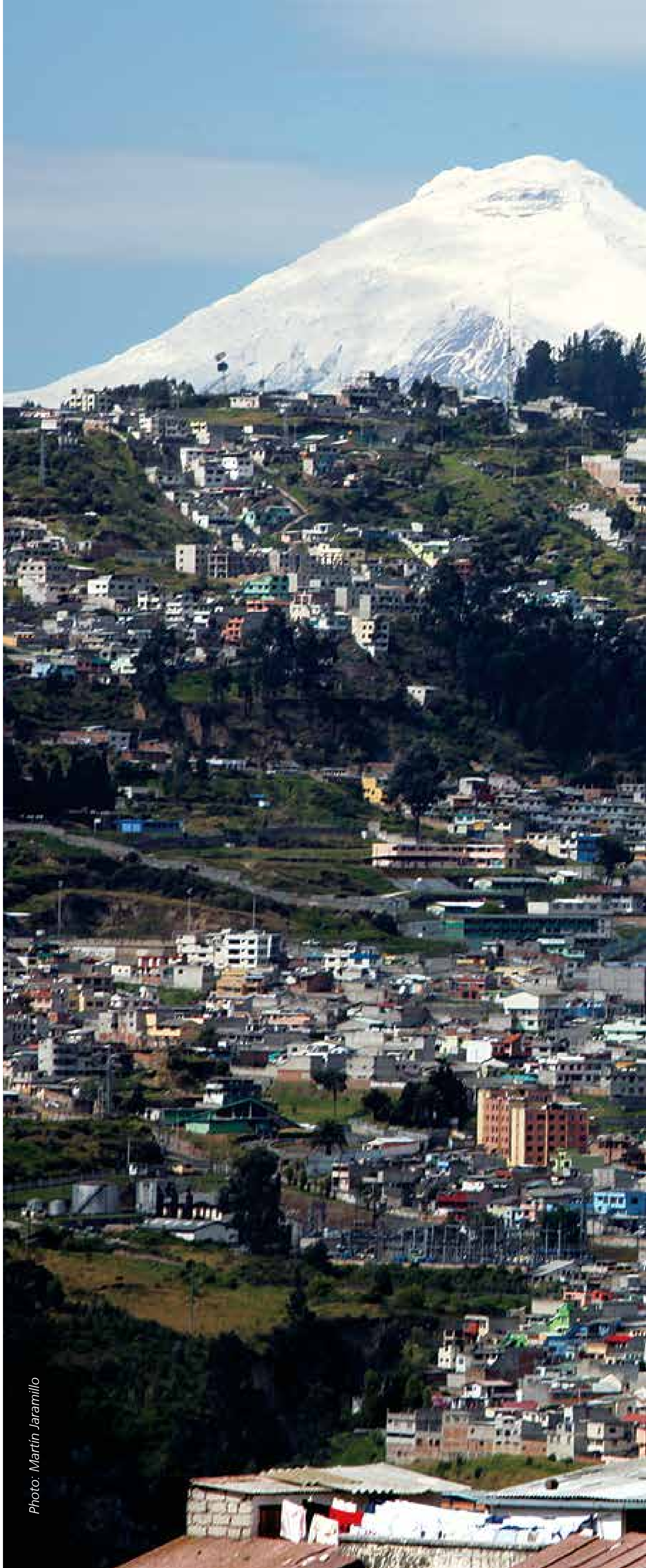
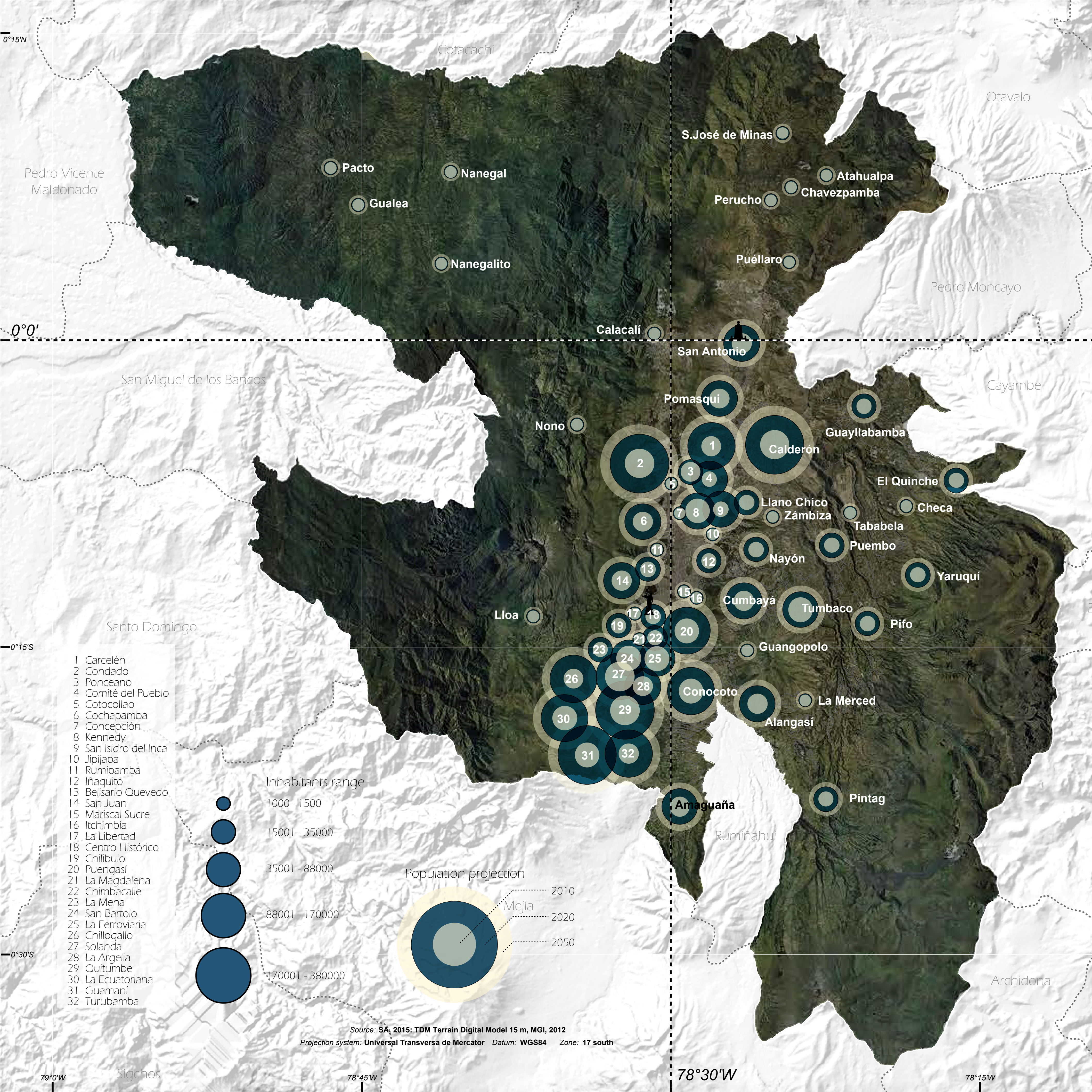


Photo: Martín Jaramillo


Urban settlements in the southeast of the MDQ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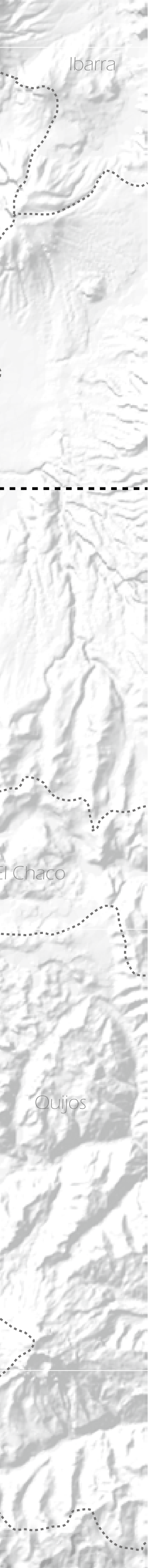
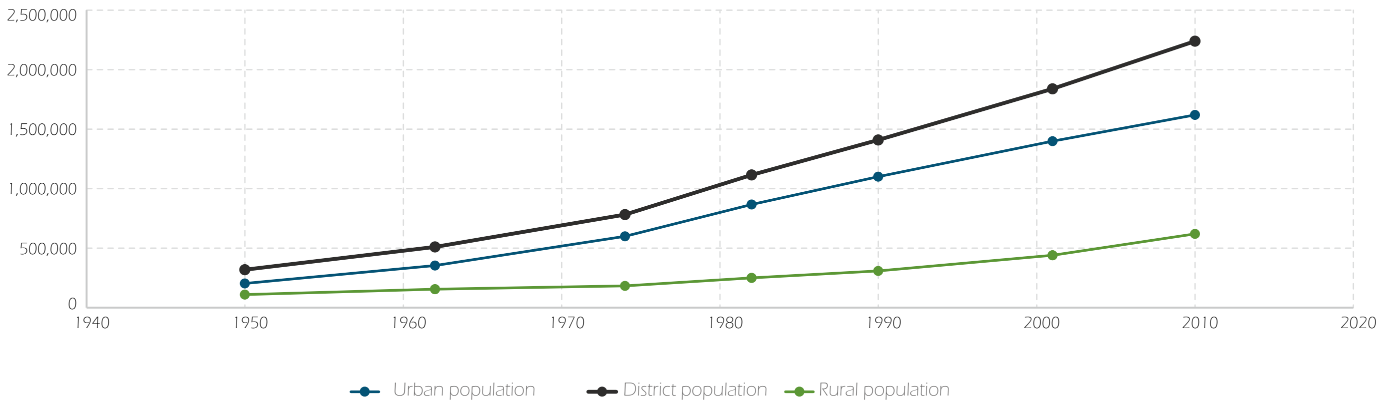
Chavezpamba
Perucho
Puéllaro
Pedro Moncayo
0°0'
Calacalí
San Antonio
San Miguel de los Bancos
Cayambe
Pomasqui
Nono
Guayllabamba
Calderón
El Quinche
Llano Chico
Zámbiza
Checa
Tababela
Puembo
Nayón
Yaruquí
Cumbayá
Tumbaco
Pifo
Lloa
Santo Domingo
Guangopolo
0°15'S
Conocoto
La Merced
Alangasí
Amaguaña
Píntag
Rumiñahui
Mejía
Archidona
0°30'S
1 Carcelén
2 Condado
3 Ponceano
4 Comité del Pueblo
5 Cotocollao
6 Cochapamba
7 Concepción
8 Kennedy
9 San Isidro del Inca
10 Jipijapa
11 Rumipamba
12 Iñaquito
13 Belisario Quevedo
14 San Juan
15 Mariscal Sucre
16 Itchimbía
17 La Libertad
18 Centro Histórico
19 Chilibulo
20 Puengasí
21 La Magdalena
22 Chimbacalle
23 La Mena
24 San Bartolo
25 La Ferroviaria
26 Chillogallo
27 Solanda
28 La Argelia
29 Quitumbe
30 La Ecuatoriana
31 Guamaní
32 Turubamba
Inhabitants range
1000 - 1500
15001 - 35000
35001 - 88000
88001 - 170000
170001 - 380000
Population projection
2010
2020
2050
Source: SA, 2015: TDM Terrain Digital Model 15 m, MGI, 2012
Projection system: Universal Transversa de Mercator Datum: WGS84 Zone: 17 south
79°0'W
Sigchos
78°45'W
78°30'W
78°15'W

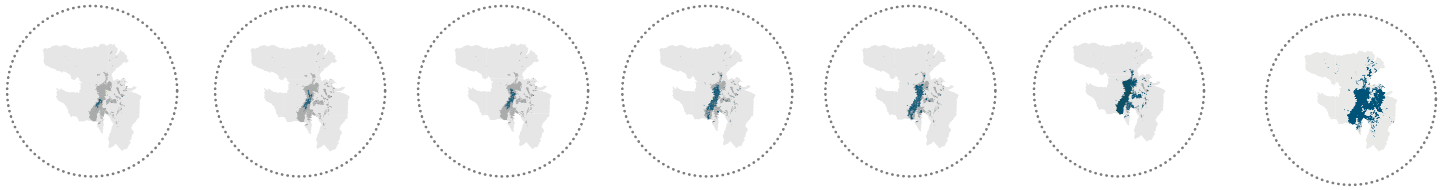


9 Map

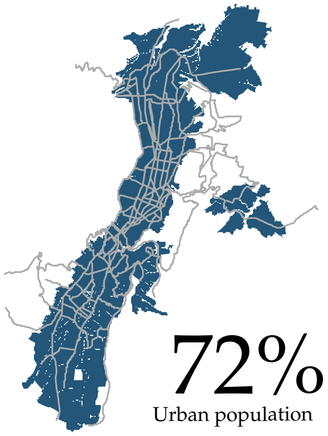
Projection of the Urban- Rural Population for the MDQ

Population growth

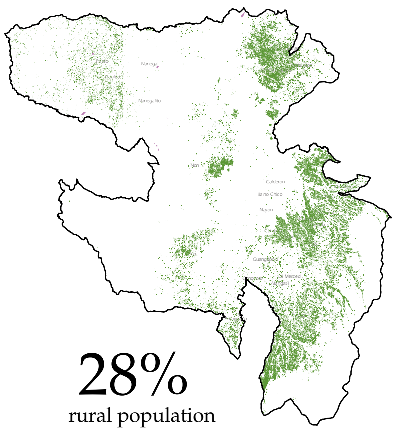




Urban area



Rural zone



Quito population

2,239,191 inhabitants

100%

	District population	Urban Population	Rural population
1950	319,221 inhabitants	209,932 inhabitants	109,289 inhabitants
1962	510,286 inhabitants	354,746 inhabitants	155,540 inhabitants
1974	782,651 inhabitants	599,828 inhabitants	182,823 inhabitants
1982	1,116,035 inhabitants	866,472 inhabitants	249,563 inhabitants
1990	1,409,845 inhabitants	1,100,847 inhabitants	308,998 inhabitants
2001	1,839,853 inhabitants	1,399,378 inhabitants	440,475 inhabitants
2010	2,239,191 inhabitants	1,619,432 inhabitants	619,759 inhabitants

centers of development. The growth rate of the same period is 4,665 ha/year (*Map 10*).

Changes in land use

The MDQ is located in the central region of the Ecuadorian Sierra, in the Andes Mountains, with a territorial constituency of 4,230 km^2. Its environment consists of a large natural heritage (60.7% of the MDQ), distributed among valleys and mountains typical of the Andes. Its western foothills form part of the el Chocó bio-geographic area whose rich biodiversity is comparable to that of Yasuní.

In the district there is a population of 2,239,191 inhabitants representing 15.5% of the national population. Its status as the political-administrative capital, the dynamics and scale of its economy and its regional, national and international connectivity define it as a hub of activities, of regional coordination and national influence and representation. This offers significant potential for tourism, production and of course for conservation.

Current and future human welfare in the MDQ depends on protecting natural capital against forms of production and consumption that undermine sustainability.

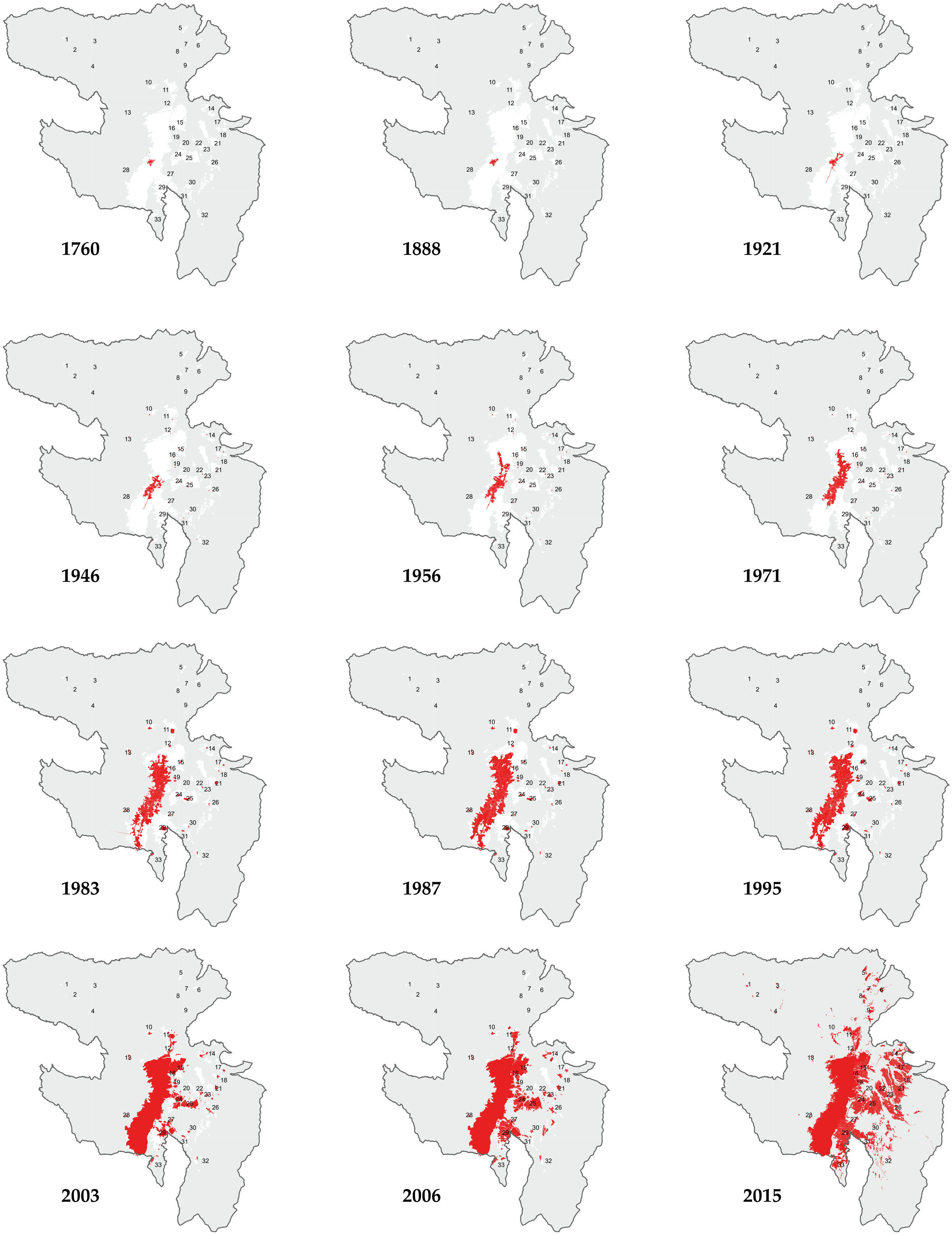
Over the last 30 years the district's socioeconomic and geopolitical dynamics have produced changing trends in land use (*Figure 7* and *Infographic 4*).

Figure 8 displays the main types of land use over a period of 29 years from 1986 through 2015, segmented into five Multi-temporal scenarios, which were recorded using remote sensing techniques in Landsat, Alos, and Rapideye satellite images and aerial photography.

Since 2001 there has been a marked tendency towards deforestation (*Map 10*) and loss of native vegetation, produced mainly by the creation of the Calacalí-La Independencia highway, which facilitates connectivity and mobility between northwestern MDQ and other regions of the country. The growth of urban and cultivated areas also evidences an accelerated dynamic of production and construction in the last five years, the area covered by low density buildings in peripheral areas has nearly doubled to a large extent due to the opening of the Mariscal Sucre airport, construction of which began in 2009 with the airport becoming operational in 2012.

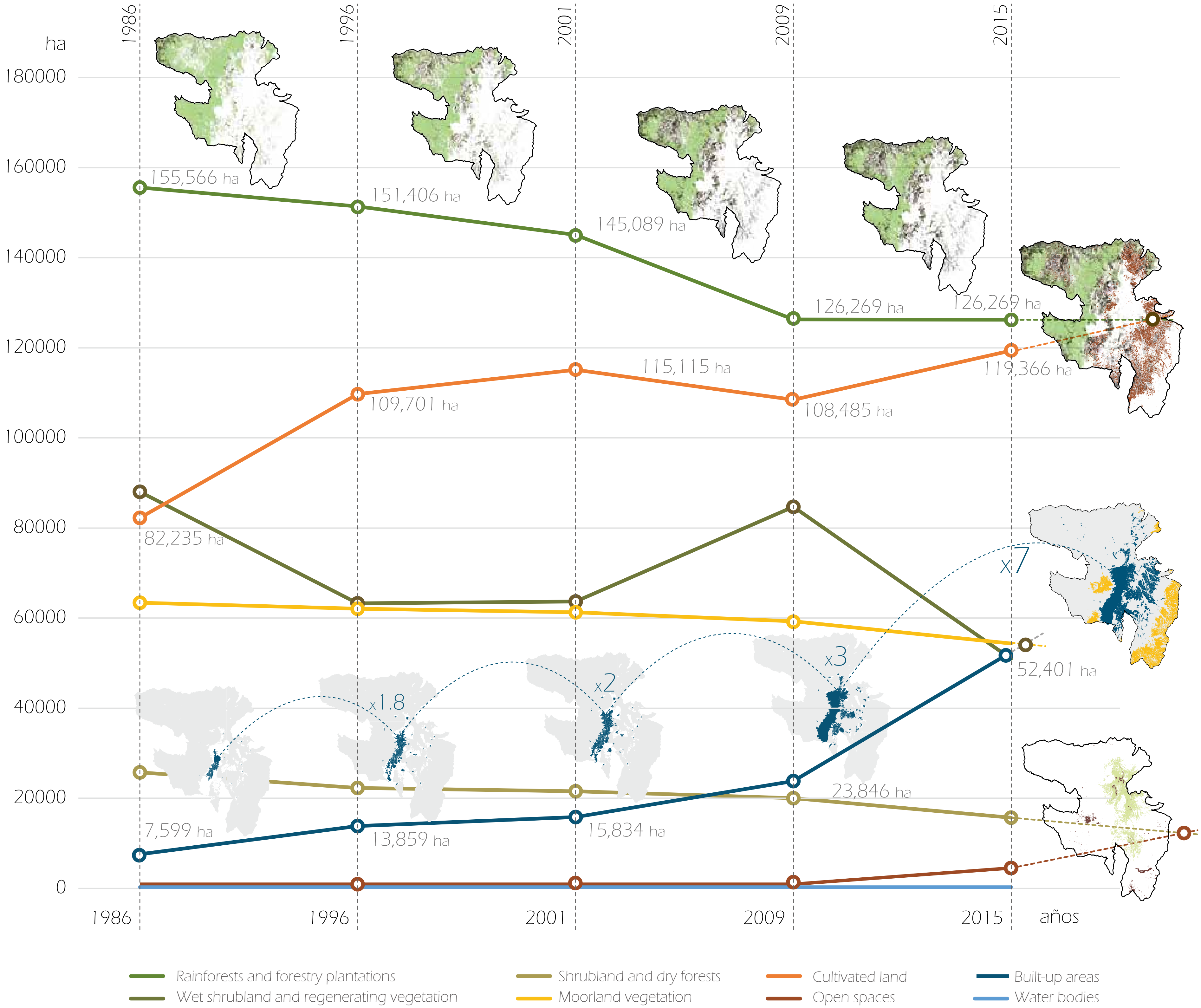
Infographic 4 shows the distributional trend for loss or increase of different types of ground cover. This illustration shows that deforestation processes existing in northwestern MDQ rainforests have tended to decline in recent years, the deforestation rate in the period 2009-2013 was 355 ha/year.

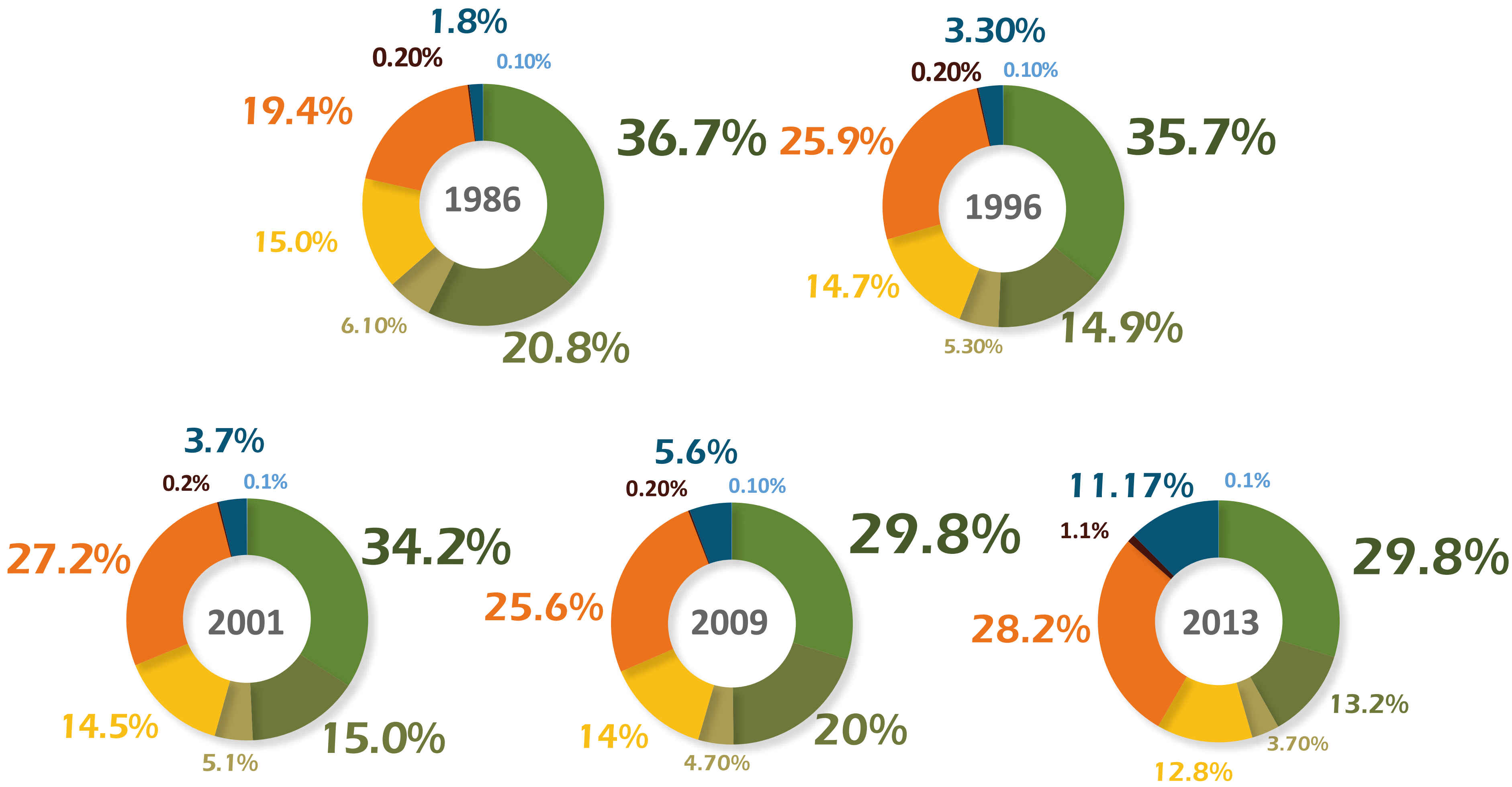
10 Map
Growth of urban sprawl



1 Pacto
2 Gualea
3 Nanegal
4 Nanegalito
5 S.José de Minas
6 Atahualpa
7 Chavezpamba
8 Perucho
9 Puéllaro
10 Calacalí
11 S.Antonio de Pichincha
12 Pomasqui
13 Nono
14 Guayllabamba
15 Calderón
16 Llano Chico
17 El Quinche
18 Checa
19 Zámbiza
20 Nayón
21 Yaruquí
22 Puembo
23 Tababela
24 Cumbayá
25 Tumbaco
26 Pifo
27 Guangopolo
28 Lloa
29 Conocoto
30 La Merced
31 Alangasí
32 Píntag
33 Amaguaña

Infographic 4. Tendency of loss or increase in soil cover 1986-2015





		1986	1996	2001	2009	2013
Rainforests and forestry plantations	ha	155,566	151,406	145,089	126,269	126,246
Wet shrubland and regenerating vegetation	ha	88,015	63,292	63,706	84,740	56,029
Shrubland and dry forests	ha	25,776	22,270	21,560	19,998	15,668
Moorland vegetation	ha	63,425	62,089	61,313	59,277	54,374
Cultivated land	ha	82,235	109,701	115,115	108,485	119,366
Open spaces	ha	927	928	929	930	4,524
Built-up areas	ha	7,599	13,859	15,834	23,846	47,340
Water bodies	ha	266	266	266	266	266

Figure 7. Main types of soil cover in the period 1986-2015
Source: Secretary of the Environment, Knowledge management, 2014.

AGROPRODUCTIVE DIVERSITY

The MDQ's agricultural production sector has a privileged geographical location as well as having little variation in the number of daylight and night-time hours throughout the year. The district also has eleven climate types with minimum temperatures of -2°C, maximum temperatures of 27°C, and rainfall ranging from 350 mm to 4,000 mm. This set of climatic conditions creates two seasons: a dry season from June to September, and a rainy season from October to May, influencing the territory's agricultural regimes and establishing specific relations between geography and the population, making it an enabling environment for the biodiversity of permanent crops in 7,868 ha of space, short-cycle crops in 9,828 ha and grazing areas in 63,858 ha.

Figure 8 shows the total percentage of the Economically Active Population working in agriculture, forestry and fishing.

Productive characteristics in the MDQ are shown in *Figure 9*.

The dynamics of the agro-productive sector are also determined by population distribution; in the MDQ only 28% of the population lives in the valleys and rural areas. Of this small percentage only 39,977 people are engaged in agriculture.

The types of crops grown in the MDQ can be seen in *Map 11*.

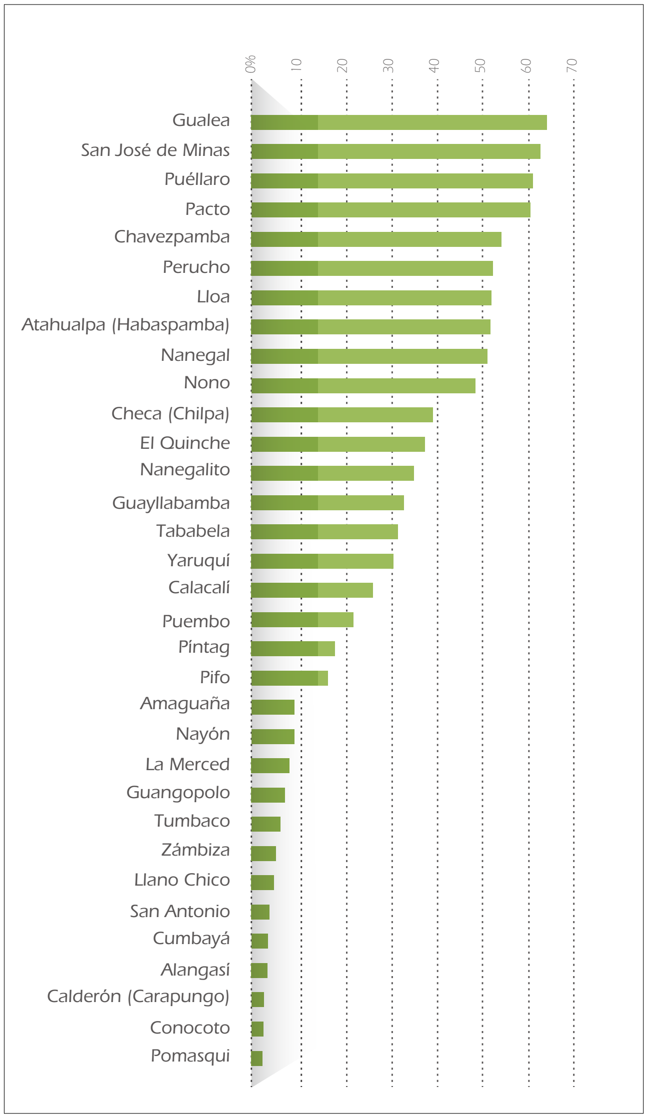


Figure 8. Percentage of economically active people working in agriculture, livestock farming, forestry and fishing in 2010.

Source: Secretary of the Environment, Study of Vegetation cover with a productive focus, 2014.

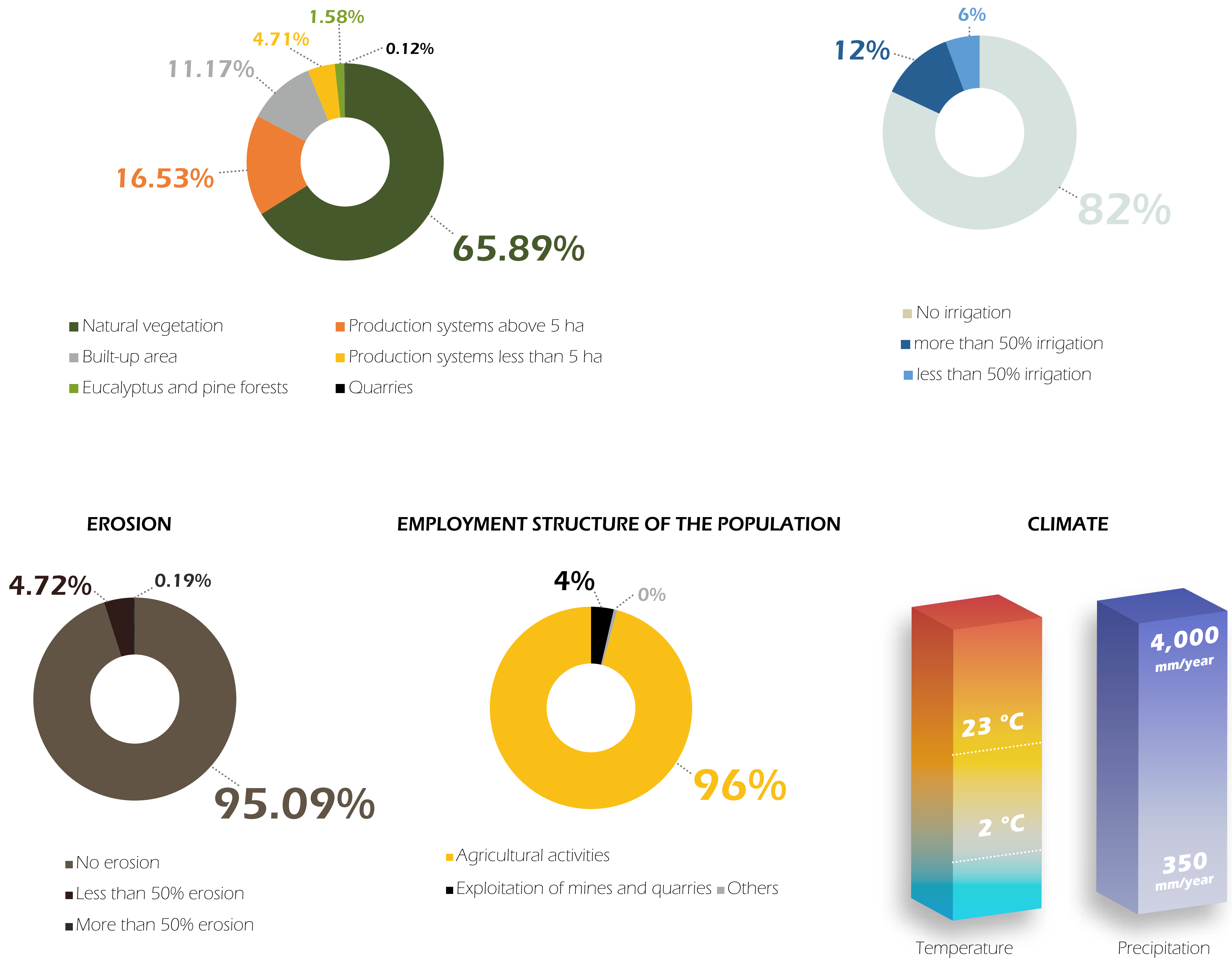
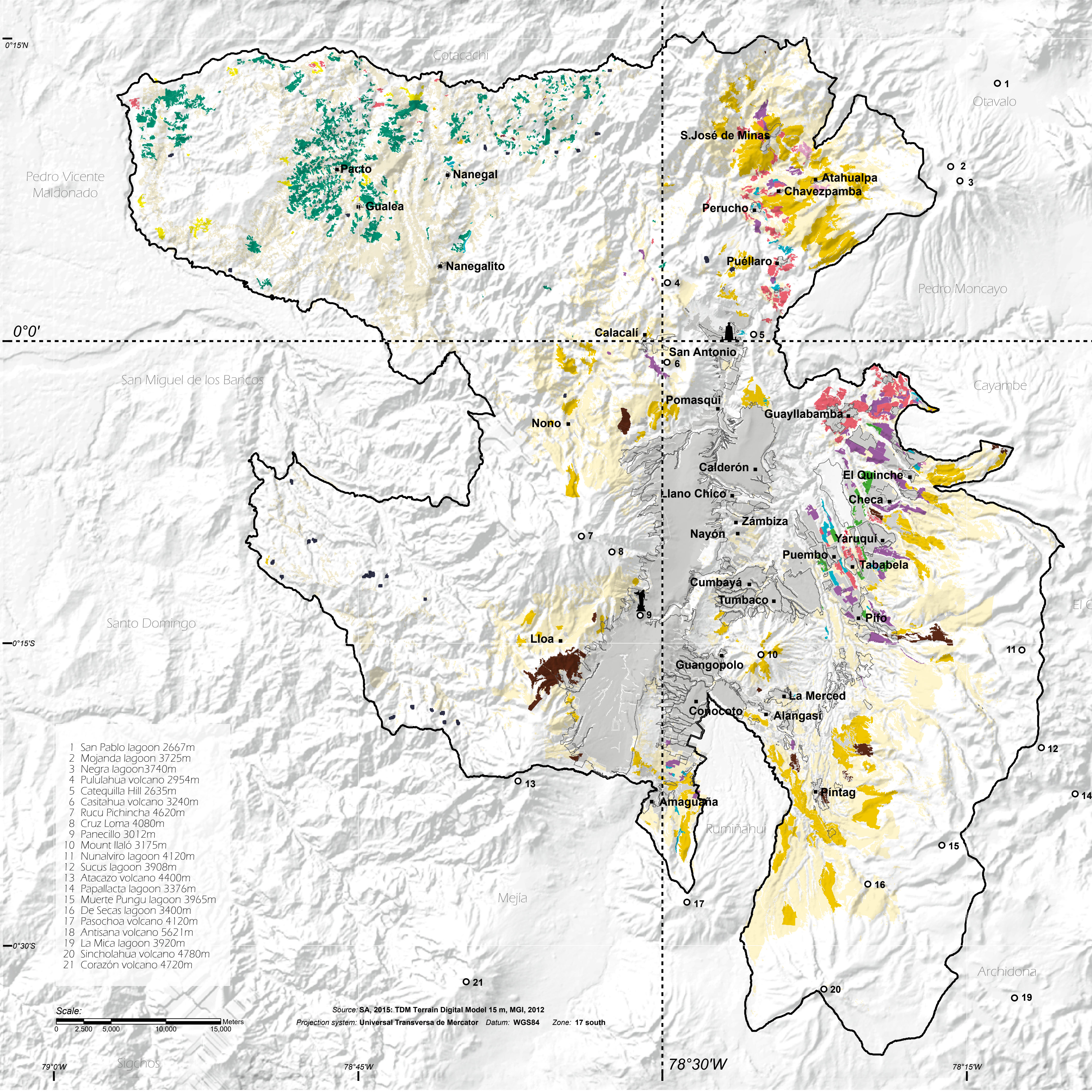


Figure 9. Production features of the MDQ
Source: Secretary of the Environment, Study of Vegetation cover with a productive focus, 2014.


0°15'N
0°0'
0°15'S
0°30'S
79°0'W
78°45'W
78°30'W
78°15'W
Cotacachi
Otavalo
Pedro Vicente Maldonado
San Miguel de los Bancos
Pedro Moncayo
Cayambe
Santo Domingo
Mejía
Rumiñahui
Archidona
Sigchos
El C
S.José de Minas
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Conocoto
Alangasí
Amaguaña
Pintag
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2 Mojanda lagoon 3725m
3 Negra lagoon3740m
4 Pululahua volcano 2954m
5 Catequilla Hill 2635m
6 Casitahua volcano 3240m
7 Rucu Pichincha 4620m
8 Cruz Loma 4080m
9 Panecillo 3012m
10 Mount Ilaló 3175m
11 Nunalviro lagoon 4120m
12 Sucus lagoon 3908m
13 Atacazo volcano 4400m
14 Papallacta lagoon 3376m
15 Muerte Pungu lagoon 3965m
16 De Secas lagoon 3400m
17 Pasochoa volcano 4120m
18 Antisana volcano 5621m
19 La Mica lagoon 3920m
20 Sincholahua volcano 4780m
21 Corazón volcano 4720m
Scale:
0 2,500 5,000 10,000 15,000 Meters
Source: SA, 2015: TDM Terrain Digital Model 15 m, MGI, 2012
Projection system: Universal Transversa de Mercator Datum: WGS84 Zone: 17 south

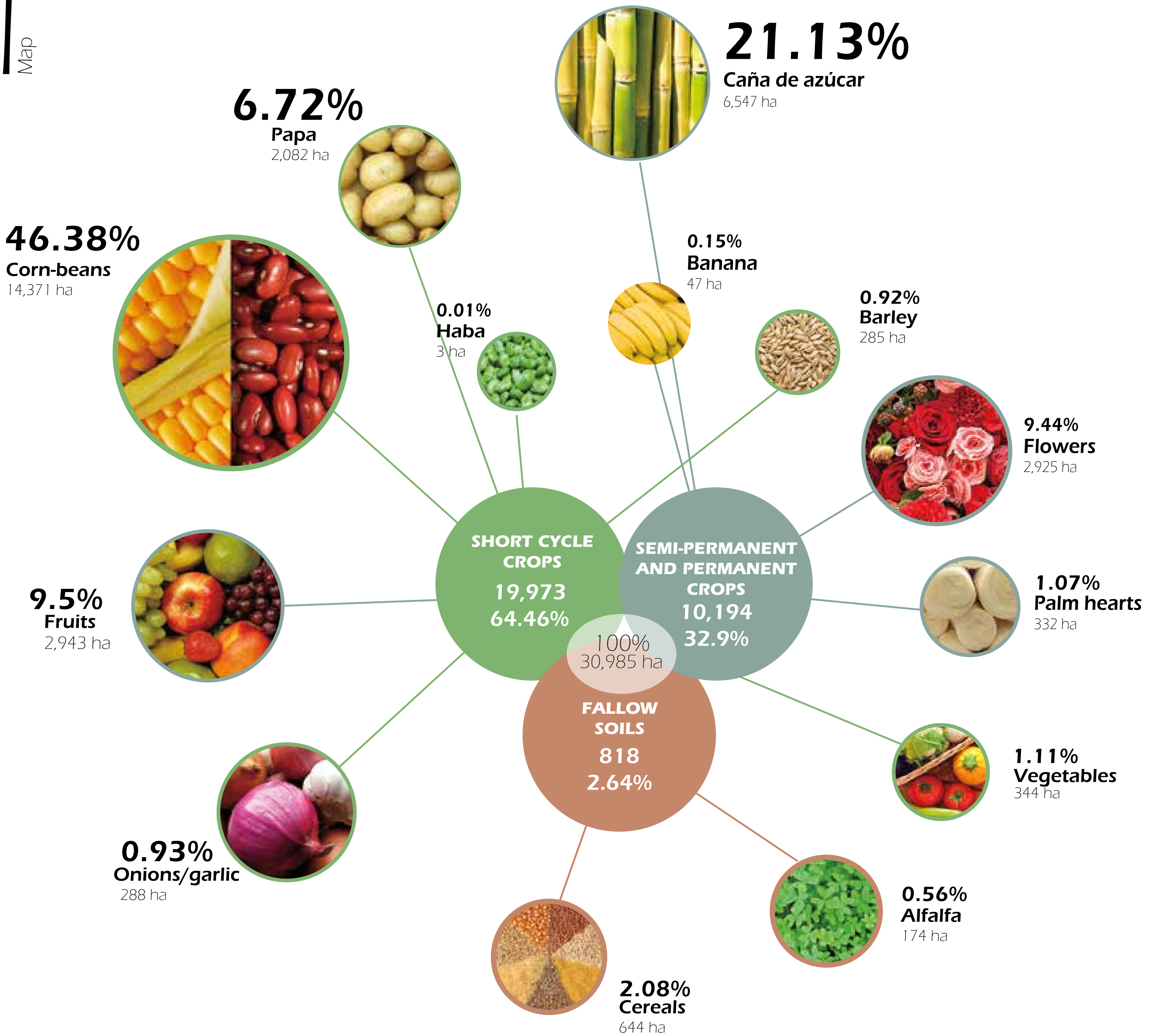
Ibarra

Chaco

Quijos

11 Map

Cultivation types in the MDQ



Infrastructure
- Floriculture farms
- Fish farms
- Pig farms
- Poultry farms

Pastures
- Highland pastures
- Pastures in tropical areas

Short cycle crops
- Strawberries
- Vegetables
- Corn/ Beans
- Potatoes

Semi-permanent and permanent crops
- Bananas
- Yucca
- Fallow land
- Sugar cane
- Fruits

Source: Secretary of the Environment, Study of Vegetation cover with a productive focus, 2014.

Production systems

Among the 423,074 ha occupied by the Metropolitan District of Quito, different productive systems are established in 88,810 ha (35.50%).

In the MDQ areas of natural vegetation are predominant, occupying 279,810.3 ha (60.7%), while agro-productive systems are established in 119,366 ha (28.2%), the built-up area occupies 47,237.23 ha (11.17%), forest plantations of pine and eucalyptus cover 6703.12 ha (1.58%), while areas intended for non-renewable resources occupy 513.29 ha (0.12%) and aquaculture covers 6.03 ha, which is too small an area to show as a percentage of the total area of the MDQ.

The predominant production system is livestock trade with 29,324.17 ha (6.93%), followed by the combined livestock system with 21,583.94 ha (5.10%) and the marginal livestock system with 11,180.91 ha (2.63%). Within the MDQ these systems are intended primarily for milk production and are located mainly in the parishes of Gualea, Nanegal and Nanegalito.

The marginal agricultural and the agricultural trade systems occupy a surface area of 3.63%, the first of these has an area of 8,131.84 ha (1.92%) and is mainly located in the parishes of Pacto, Puéllaro and Píntag, and the second occupies an area of 7,214.63 ha (1.71%) and is to a large extent located in the parishes of the Pacto, San José de Minas and Nanegal.

The combined agricultural system has an area of 5,673.85 ha (1.34%) and is mainly distributed in the parishes of Pacto, San José de Minas, Guayllabamba and Gualea.

The agricultural enterprise system occupies an area of 3,343.06 ha (0.79%) and is located mainly in the parishes of Pifo, Guayllabamba, Yaruquí, El Quinche and Checa. It is noteworthy that within this system the cultivation of flowers in both greenhouse conditions and in the open is predominant.

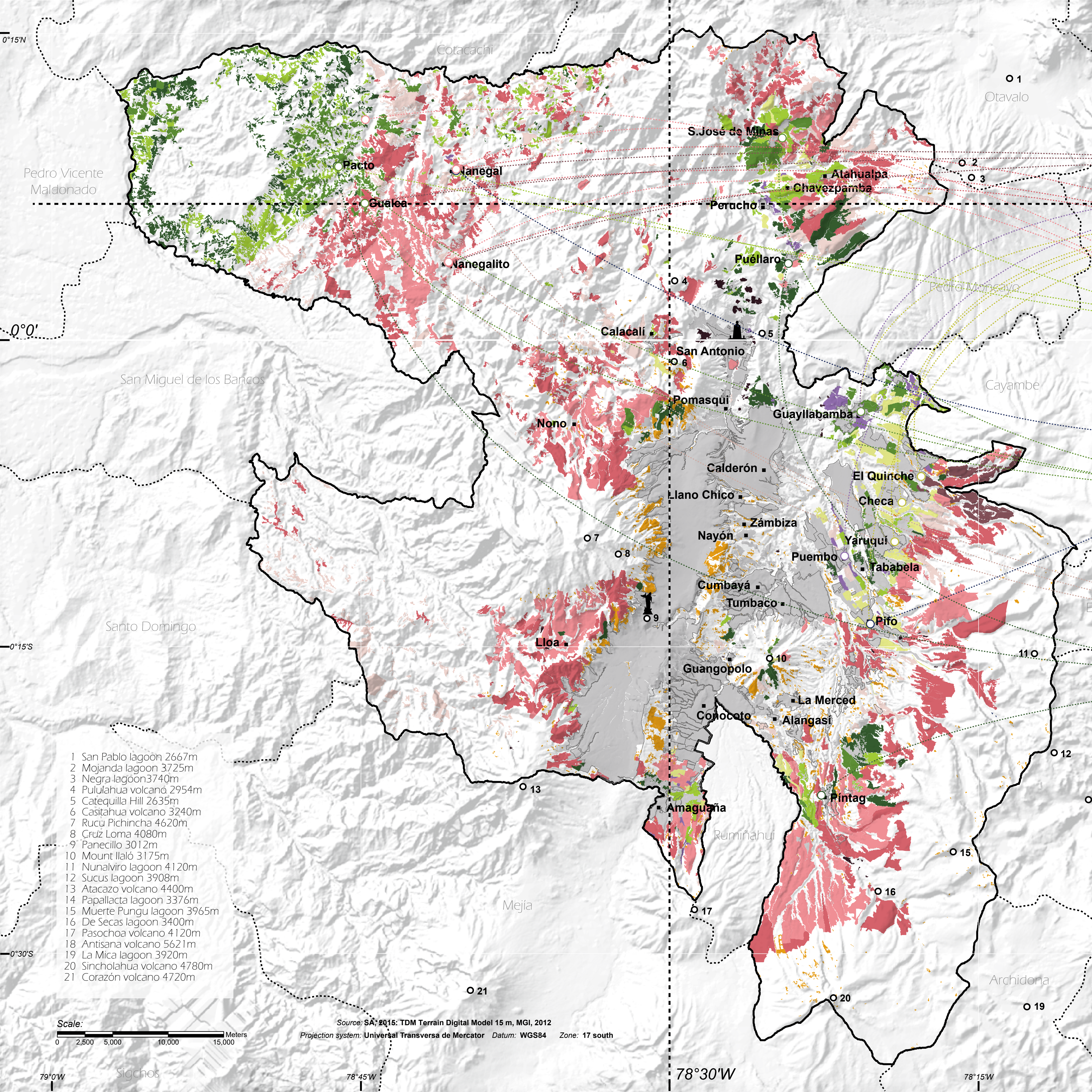
The livestock enterprise system has an area of 1,349.41ha (0.32%) and is centered in the parish of El Quinche.

The poultry enterprise system occupies an area of 1,074.21 ha (0.25%) and is predominantly in the parishes of Guayllabamba and Puembo. This system dominated by the presence of an infrastructure of sheds.

The commercial aquaculture system is found in the parishes of Pifo and Nanegal and occupies a total area of 6.03 ha (0.001%) (*Map 12*).

Photo: Metropolitan News Agency

Agricultural plots in the MDQ


0°15'N
Cotacachi
Otavalo
Pedro Vicente Maldonado
S.José de Minas
Pacto
Nanegal
Atahualpa
Chavezpamba
Gualea
Perucho
Nanegalito
Puéllaro
Pedro Moncayo
0°0'
Calacalí
San Antonio
San Miguel de los Bancos
Cayambe
Pomasqui
Guayllabamba
Nono
Calderón
El Quinche
Llano Chico
Checa
Zámbiza
Nayón
Yaruquí
Puembo
Tababela
Cumbayá
Tumbaco
Santo Domingo
Pifo
0°15'S
Lloa
Guangopolo
La Merced
Conocoto
Alangasí
Píntag
Amaguaña
Rumiñahui
Mejía
Archidona
0°30'S
1 San Pablo lagoon 2667m
2 Mojanda lagoon 3725m
3 Negra lagoon3740m
4 Pululahua volcano 2954m
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6 Casitahua volcano 3240m
7 Rucu Pichincha 4620m
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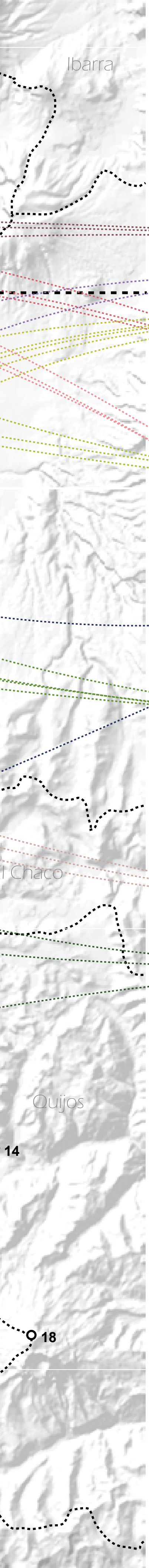
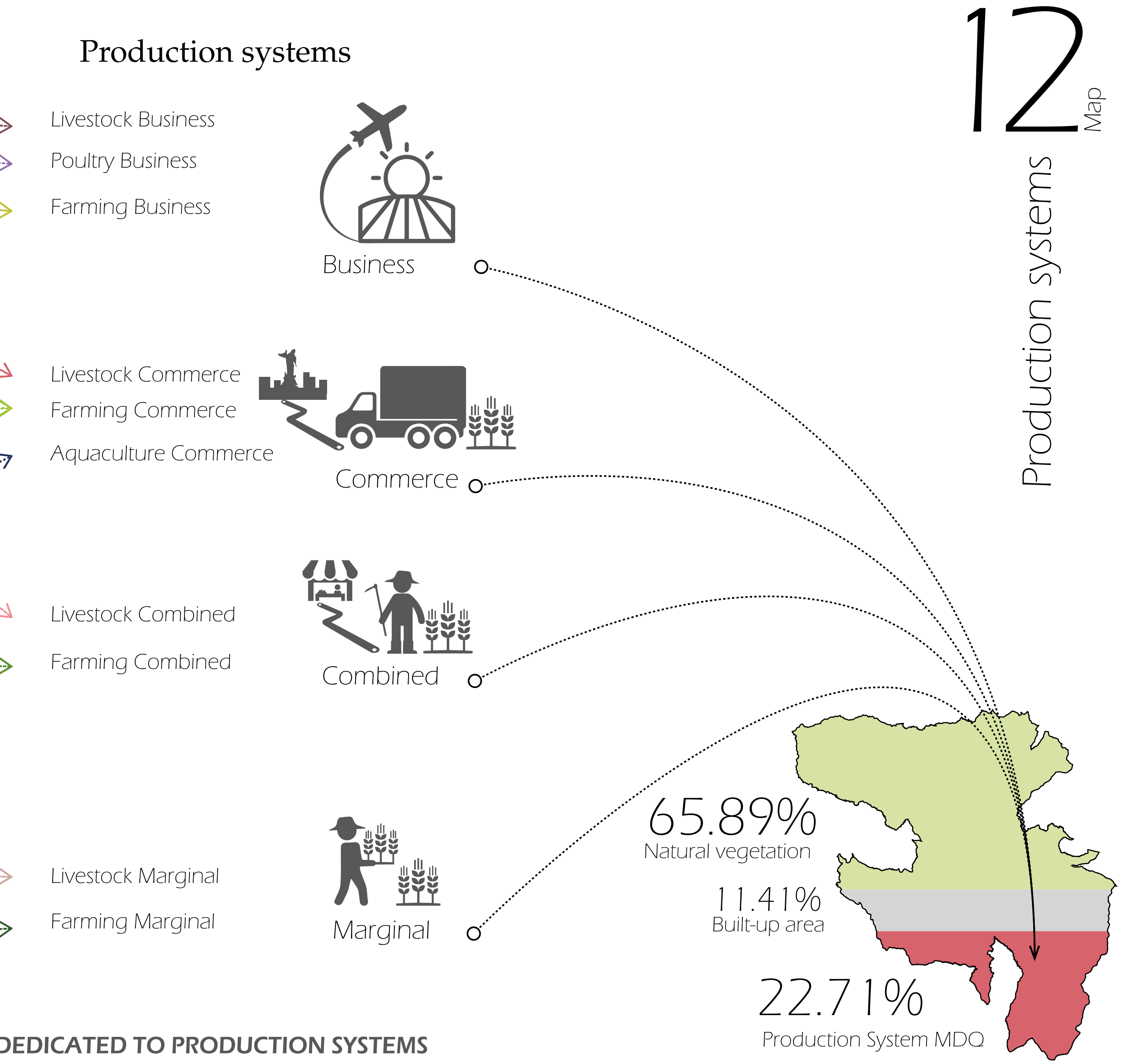
9 Panecillo 3012m
10 Mount Ilaló 3175m
11 Nunalviro lagoon 4120m
12 Sucus lagoon 3908m
13 Atacazo volcano 4400m
14 Papallacta lagoon 3376m
15 Muerte Pungu lagoon 3965m
16 De Secas lagoon 3400m
17 Pasochoa volcano 4120m
18 Antisana volcano 5621m
19 La Mica lagoon 3920m
20 Sincholahua volcano 4780m
21 Corazón volcano 4720m
Scale:
0 2,500 5,000 10,000 15,000 Meters
Source: SA, 2015: TDM Terrain Digital Model 15 m, MGI, 2012
Projection system: Universal Transversa de Mercator Datum: WGS84 Zone: 17 south
79°0'W
Sigchos
78°45'W
78°30'W
78°15'W

12 Map

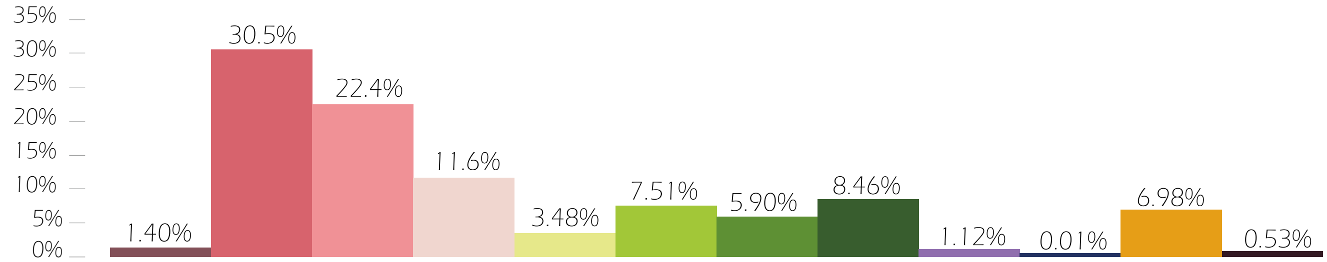
Production systems



Production systems



AREA (ha) DEDICATED TO PRODUCTION SYSTEMS



Areas	ha	1,349.41	29,324.17	21,583.94	11,180.91	3,343.06	7,214.63	5,673.85	8,131.84	1,074.21	6.03	6,703.12	513.29
MDQ Percentage	%	0.32%	6,93%	5.10%	2.63%	0.79%	1.71%	1.34%	1.92%	0.25%	0.001	1.58%	0.12%

- Livestock Business
- Livestock Commerce
- Livestock Combined
- Livestock Marginal
- Farming Commerce
- Farming Commerce
- Farming Combined
- Farming Marginal
- Poultry Business
- Aquaculture Commerce
- Eucalyptus and Pine Forest
- Quarry

Source: Secretary of the Environment, Study of Vegetation cover with a productive focus, 2014.

Part II
FOOTPRINT OF THE CITY

Nowadays, cities are suffering the consequences of urban growth affecting the environment and its natural resources. The MDQ is no stranger to this reality. Consumption and pollution, increased migration from rural areas to the city and climate variation leave a footprint on the environment. Territorial Management is essential; with consideration for the environment it is crucial to modify consumption habits, build constructions that consider environmental criteria, use less polluting public transport and integrated waste management, among other activities, to ensure a sustainable future for generations to come.
Arias Verónica 2016.

Photo:Metropolitan News Agency

Independence Plaza, Quito Historic Center.

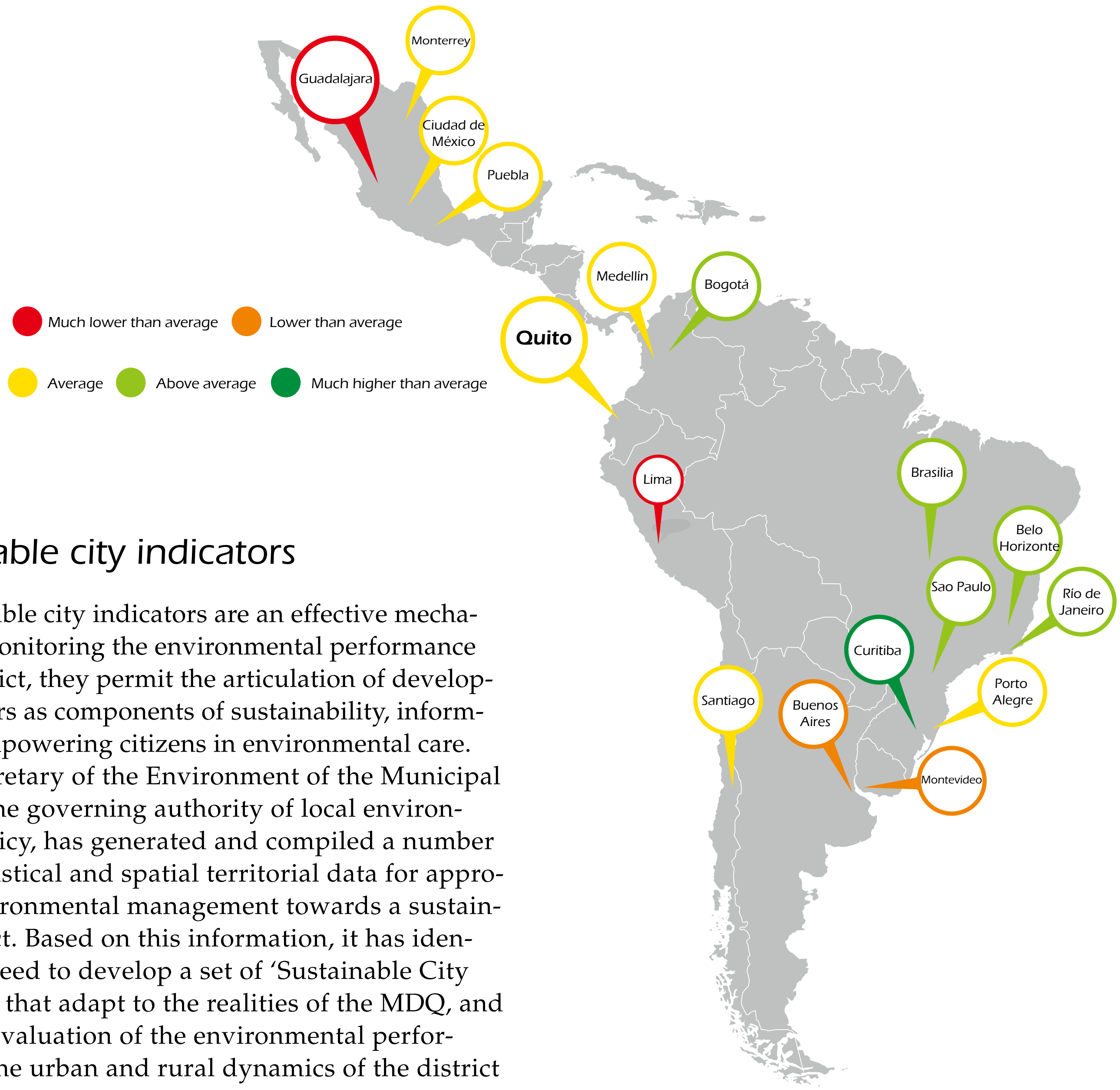
GREEN CITY INDEX

Indexes and indicators associated with sustainability are key tools for the environmental management of a city; they serve to define clear short and long term objectives and goals and to periodically assess achievements and progress.

Globally, there are several initiatives for the construction of these indicators and indexes. On the subject of the environment, the 'Green City Index' can be highlighted, an initiative promoted by the German company Siemens, which has achieved the participation of more than 130 cities around the world, located on five continents (Economist Intelligence Unit, 2012).

The Green City Index allows comparisons of environmental sustainability in the various participating cities in key areas of management, such as air quality, environmental governance, CO_2, energy, buildings, transport, waste, land use and water. The methodology for calculating this index provides quantitative and qualitative indicators.

In Latin America 17 cities participated in the Index, including Quito, the results for which show an average environmental performance for the region, as displayed in *Infographic 1*. Quito's results show areas with high ratings, such as air quality, and others with low values, such as sanitation, revealing strengths and weaknesses, which translate into opportunities and challenges (Economist Intelligence Unit, 2010).



Infographic 1. *Average environmental performance of Latin American cities.*

Source: Economist Intelligence Unit, 2010.

Sustainable city indicators

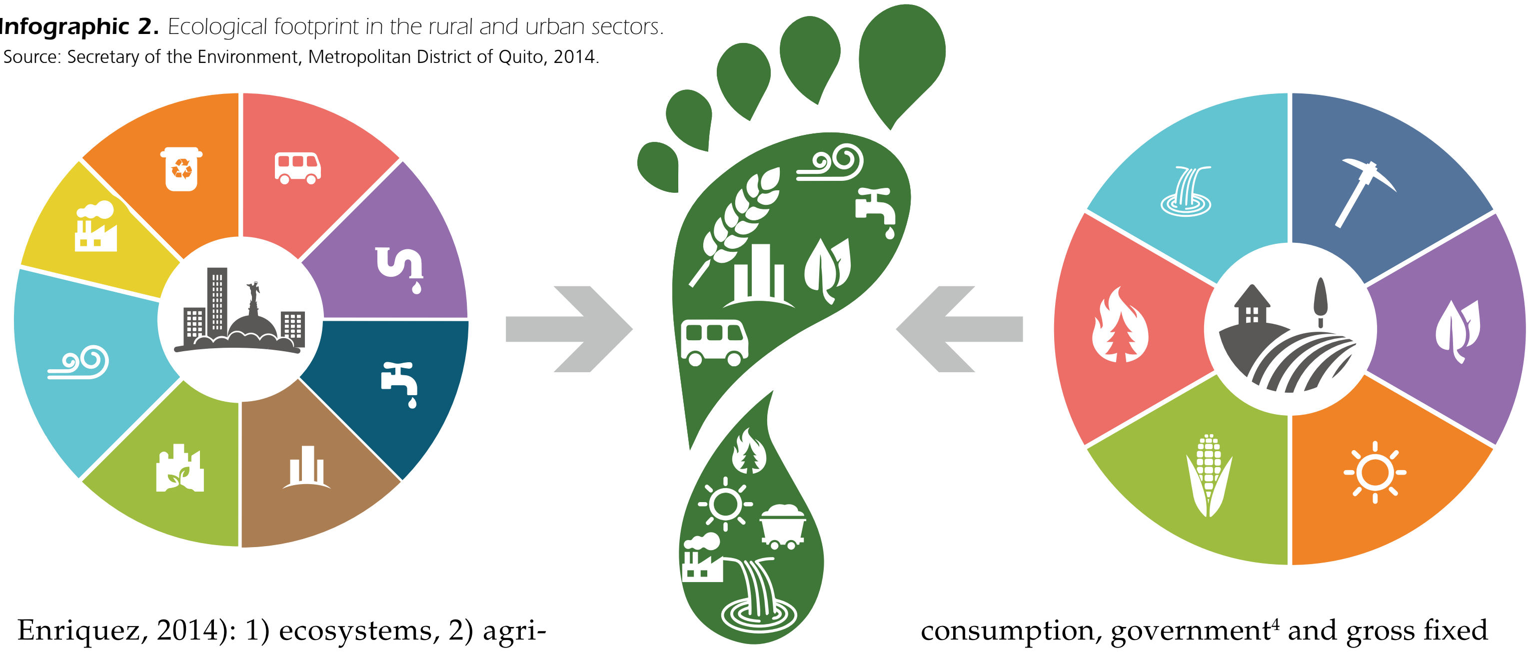
Sustainable city indicators are an effective mechanism for monitoring the environmental performance of the district, they permit the articulation of development sectors as components of sustainability, informing and empowering citizens in environmental care.

The Secretary of the Environment of the Municipal MDQ, as the governing authority of local environmental policy, has generated and compiled a number of key statistical and spatial territorial data for appropriate environmental management towards a sustainable district. Based on this information, it has identified the need to develop a set of 'Sustainable City Indicators' that adapt to the realities of the MDQ, and allow the evaluation of the environmental performance of the urban and rural dynamics of the district in a comprehensive, participatory and systematic manner. From these data the 'carbon footprint' and 'water footprint' of the urban area of the MDQ were also measured.

These indicators permit knowledge of the state of the MDQ in relation to the environment and sustainable development, and establish a clear baseline for defining policies and strategies to build a sustainable Quito, which is effectively reflected in the new model of sustainable territorial development embodied by the Metropolitan Territorial Management Plan 2015-2025 (MTMP).

Urban indicators (Siemens, 2013) were selected based on the Green City Index, with variants conforming to the reality of the city: 1) energy and CO_2, 2) land use and territorial management, 3) transport, 4) integrated solid waste management, 5) potable water, 6) sanitation, 7) air quality, and 8) urban agriculture. The rural indicators contain variants fitting the natural environment (J. Vaca, N. Narvaez, D.

Infographic 2. Ecological footprint in the rural and urban sectors.
Source: Secretary of the Environment, Metropolitan District of Quito, 2014.



Enriquez, 2014): 1) ecosystems, 2) agriculture, 3) protection of water sources, 4) use of aggregate rock and mineral mining, 5) forest management risks, and 6) vulnerability to climate change.

Each of the sectors considered has a number of quantitative[1] and qualitative[2] indicators serving to complement each other.

The indicator for 'ecological footprint' is incorporated for the analysis of the relationships and interdependencies between rural and urban areas with a focus on sustainable development and civic responsibility towards environmental degradation[3]. This is divided into three specific demands: household consumption, government[4] and gross fixed capital formation[5]. The ecological footprint associated with households, or the domestic footprint, is divided into five categories: food, housing, transportation, goods and services.

Infographic 2 shows the analysis structure of urban and rural indicators and their relationship with the ecological footprint.

Within the defined structure for indicators of the sustainable city, shown in *Infographics 3 and 4*, in the ensuing analysis the results for the urban and rural sectors and ecological footprint are presented[6].

According to the individual results of the selected indicators, the overall environmental performance of the urban sector in the MDQ is placed at medium level. According to the individual results of the indicators chosen the overall environmental performance of the rural sector of the MDQ is also placed at medium level.

1 Quantitative indicators: the value registered as an indicator of an analysis sector is compared and evaluated in relation to its degree of impact, which can be analyzed according to various kinds of standards, temporality criteria and regional assessment.
2 Qualitative indicators are based mainly on environmental policies and strategies established in the various public and private institutions and corresponding with the appropriate analysis sectors.
3 In accordance with the Global Footprint Network (2012), the ecological footprint measures the amount of biologically productive land and water that an individual, a region, all of humanity, or a certain human activity requires to produce the resources consumed and absorb the waste generated.
4 Consumption paid for by the government for public educational materials for schools, police, ministries, etc.
5 Investments such as the construction of buildings, roads, factories and equipment.
6 Only the results for quantitative indicators are displayed. The data come from the Sustainable City Indicators report (Secretary of the Environment, Metropolitan District of Quito, 2014) which shows the environmental performance of quantitative and qualitative indicators in more detail.

Infographic 3. Urban Indicators

Integrated solid waste management

The indicator presents very similar results to the regional average. A slight tendency towards improvement over time is observed. **96.5** %

The quantity of waste generated per person has been increasing mildly during recent years. Nonetheless, the values are still lower than the regional average (475.4 kg/ inhabitant*year) Kg/[inhabitant*year] **309.1**

Energy and CO_2

The MDQ performs well compared to the regional average. Moreover, a decrease in the emission per capita versus the previous results (2011 vs. 2007) is observed. ton CO_2-eq/inhabitant **707.5**

An energy intensity very similar to the regional average is discerned, i.e. the MDQ results are very competitive from the point of view of wealth creation. MJ/1000 USD **2.55**

Air quality

The annual average of NO_2 is within the limits established by the WHO for air quality. (<40 µg/m³). (µg /m³) **28.6**

The 10 minute averages for SO_2 are within the limits established by the WHO for air quality (less than 500 ug/m³). (µg /m³) **394.5**

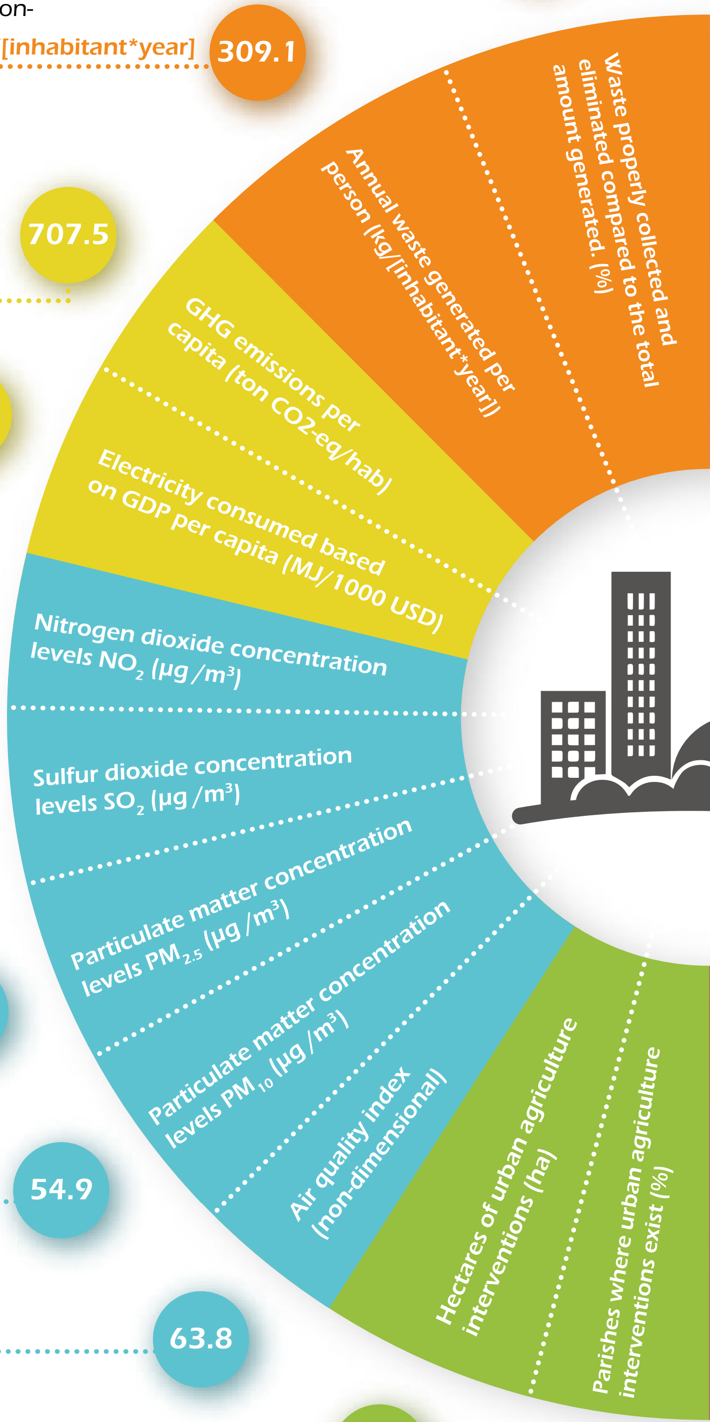
The annual averages of $PM_{2.5}$ are positioned within the values of the WHO's intermediate objective 3 (15-25 ug/m³); nevertheless, they are still not within the limits set by the WHO guidelines for air quality (<20 ug/m³). (µg /m³) **20.8**

The annual averages of PM_{10} stand within the values of the WHO's intermediate objective 1 (50-70 ug/m³); however, they are still not within the limits set by the WHO guidelines for air quality (<20 ug/m³). (µg /m³) **54.9**

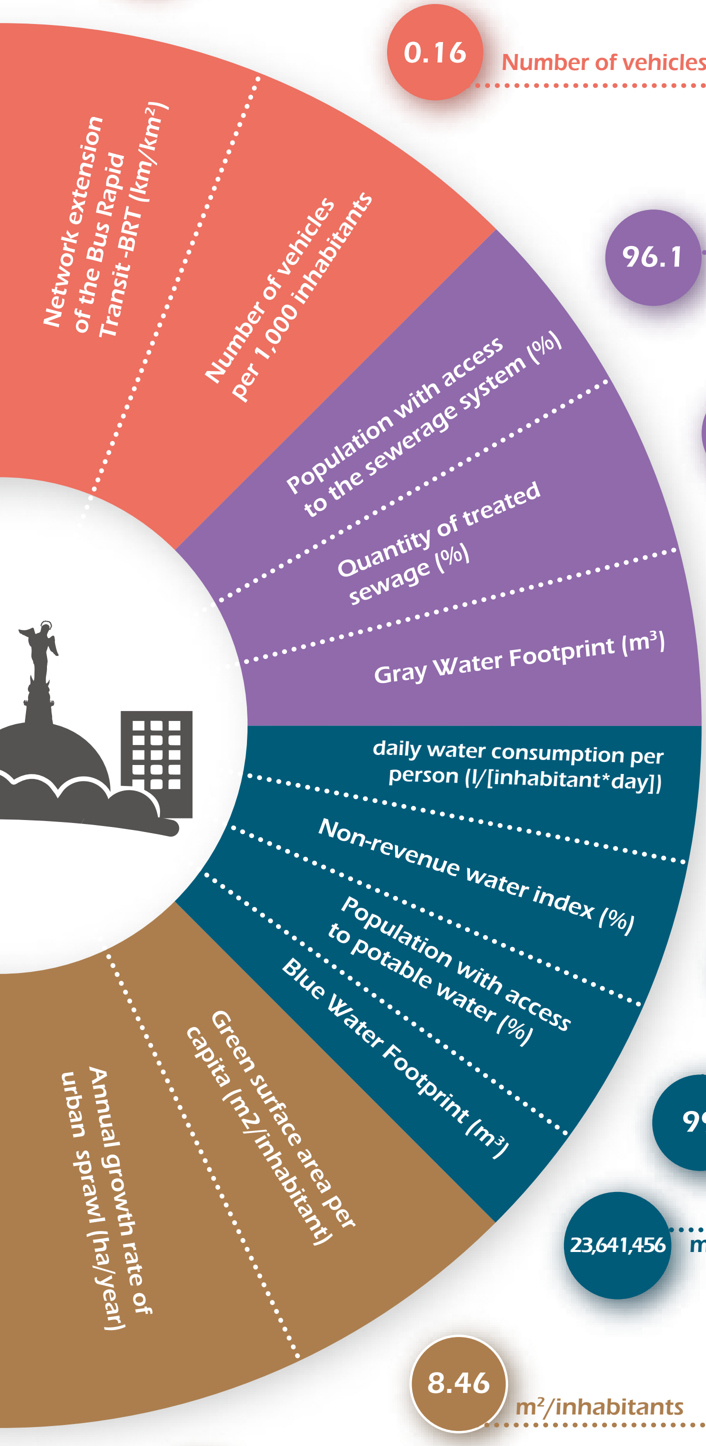
During the year 2015, air quality was maintained at levels considered to be 'good'; the Quitenian Index for Air Quality is situated between 500 and 100, lower than the values established by the Ecuadorian air quality standards. **63.8**

Urban agriculture

This indicator is not evaluated due to the lack of reference data for comparison. Values are useful as a baseline for future evaluations. ha **1,342** % **20.2**



Environmental performance: Very bad Bad



Transport

This indictor has not varied from its last evaluation (2009) and shows very similar values to the regional average ($0.12 km/km^2$).

0.15 (km/km^2)

This indicator has increased by approximately 30% compared to the previous result. However, it is still considerably lower than the regional average (0.31 vehicles/inhabitant).

0.16 Number of vehicles per 1,000 inhabitants

Sanitation

Access to the sewerage system for the MDQ population has not varied significantly during the last few years; the actual value is very similar to the regional average.

96.1 %

In the MDQ there is no wastewater treatment system. Therefore, the environmental performance of this indicator is very low.

1 %

According to the sustainability analysis for the Gray Water Footprint, the water naturally available is less than the Gray WF; hence, the water basins have no capacity to assimilate the organic pollutants generated in the MDQ. This implies that the city is not sustainable in terms of Gray WF.

1,010,968 m^3

Potable water

The use of water in the MDQ is still above the WHO recommendations (50-100 liters). Nonetheless, this consumption is considerably lower than the regional average (268.5 liters). In addition, a decreasing tendency of this indicator compared to previous results has been observed.

189.1 l/[inhabitants*day]

The non-revenue water index has decreased during the last few years. Moreover, it shows lower values than the average for the cities of the region (34.7%).

27.8 %

Access to potable water is practically 100%; hence this indicator shows a very good performance.

99 %

According to the sustainability analysis of the Blue Water Footprint, the use of water by the MDQ population is much lower than the quantity of water on offer.

23,641,456 m^3

Land use and territorial management

The amount of green surface area in the MDQ is well above WHO guidelines ($9m^2$/inhabitant) and presents values similar to the regional average. Nevertheless, there are urban parishes that do not comply with WHO recommendations.

8.46 m^2/inhabitants

An energy intensity very similar to the regional average is discerned, i.e. the MDQ results are very competitive from the point of view of wealth creation.

1,472 ha/year

+ Medium +- Good ++ Very good

Source: Secretary of the Environment, Green City Index (J. Vaca, N. Narvaez, D. Enriquez, 2014)

Infographic 4. Rural Indicators

Protection of water sources

According to the analysis of the National Water Fund (Fonag), it is necessary to actively restore 7,728 ha for water source protection. Presently, 33.6% of this goal has been reached, meaning that substantial progress has been accomplished during recent years. Nevertheless, these processes must be strengthened to get closer to the final goal.

% 33.6

Forest risks (fires)

Compared to the multi-annual average of hectares of grassland burned per year (377.5 ha/year), recent results show low levels of burning for this type of vegetation.

ha/year 8.8

Compared to the multi-annual average of hectares of dry shrubland burned per year (370.6 ha/year), recent results show high levels of burning for this type of vegetation.

ha/year 454.3

Regarding the multi-annual average of hectares of scrubland burned per year (267.2 ha/year), recent results show low levels of burning for this type of vegetation.

ha/year 31.4

With reference to the multi-annual average of hectares of eucalyptus burned per year (87.8 ha/year), recent results show low levels of burning for this type of vegetation.

ha/year 96.4

Agriculture

Indicators are not evaluated due to a lack of reference data for comparison. The values are useful as a baseline for future evaluations.

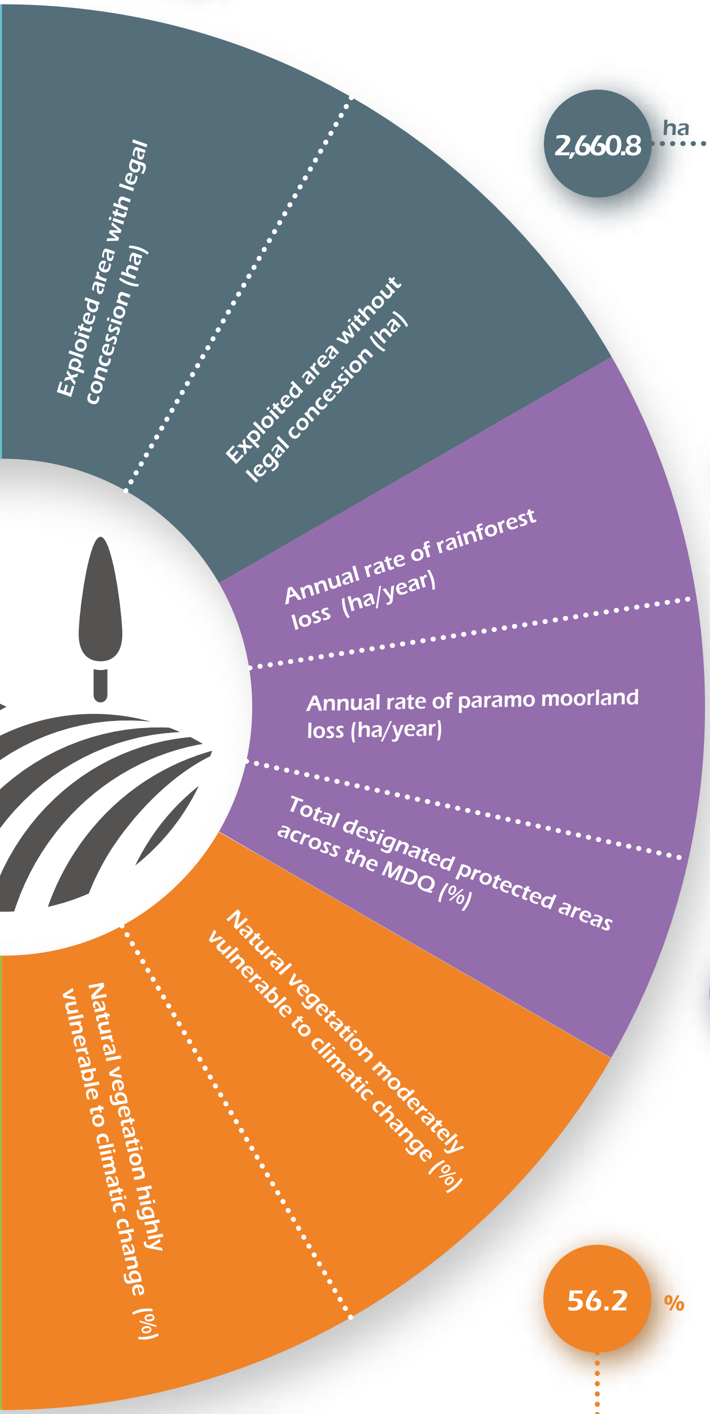
21.13 %

6.72 %

46.34 %

9.50 %

Environmental performance: - - Very bad - Bad



2,482.5 ha

2,660.8 ha

Exploitation of aggregate rock and mineral mining

In order to analyze the environmental performance of this sector, hectares of legally exploited land (with concession) are analyzed together with areas of illegally exploited land (without concession). Illegal exploitation is higher than legal exploitation, implying that more than 50% of the total amount of rock mining in the MDQ is non-technically extracted, which represents a series of very high risks. In addition, should this trend continue, whichever sector in the MDQ performing activities in aggregate rock and mineral mining may be subject to different types of risks and damages to the environment.

Ecosystems

1,086 ha/year

The rate of rainforest loss (2001-2009) shows an increase compared to the previous period (1996-2001), as well as to the average in the last 27 years (1986-2013).

335.2 ha/year

The rate of paramo moorland loss (2001-2009) shows a strong increase compared to the previous period (1996-2001), as well as to the average in the last 27 years (1986-2013).

31.5 %

At the beginning of 2011, a process of designation of protected metropolitan areas began. This has allowed a considerable increase in the quantity of protected areas in the MDQ. It has been proposed that by 2022 more than 70% of the territory should receive some degree of conservation; as such these actions should be maintained over time.

Vulnerability to climate change

56.2 %

0.3 %

The environmental performance of these indicators has been jointly performed. It has been observed that more than half of the natural vegetation of the MDQ (56.2%) is moderately vulnerable to the climatic change, for which reason it is considered that, in general terms, the MDQ situation with regard to vulnerability is medium. The percentage of vegetation highly vulnerable to climatic change is insignificant; confirming vulnerability of the MDQ territory at a medium level ranking.

Medium Good Very good

Source: Secretary of the Environment, Green City Index (J. Vaca, N. Narvaez, D. Enriquez, 2014)

Ecological footprint indicators

The 'ecological footprint' is an indicator used for the measurement of the ecological impact on global hectares (gha) for comparison with biocapacity[7], which is the regenerative capacity of nature or 'ecological budget'. In this manner, one can determine whether human living is within the ecological limits of the planet (Ministry of the Environment, 2013).

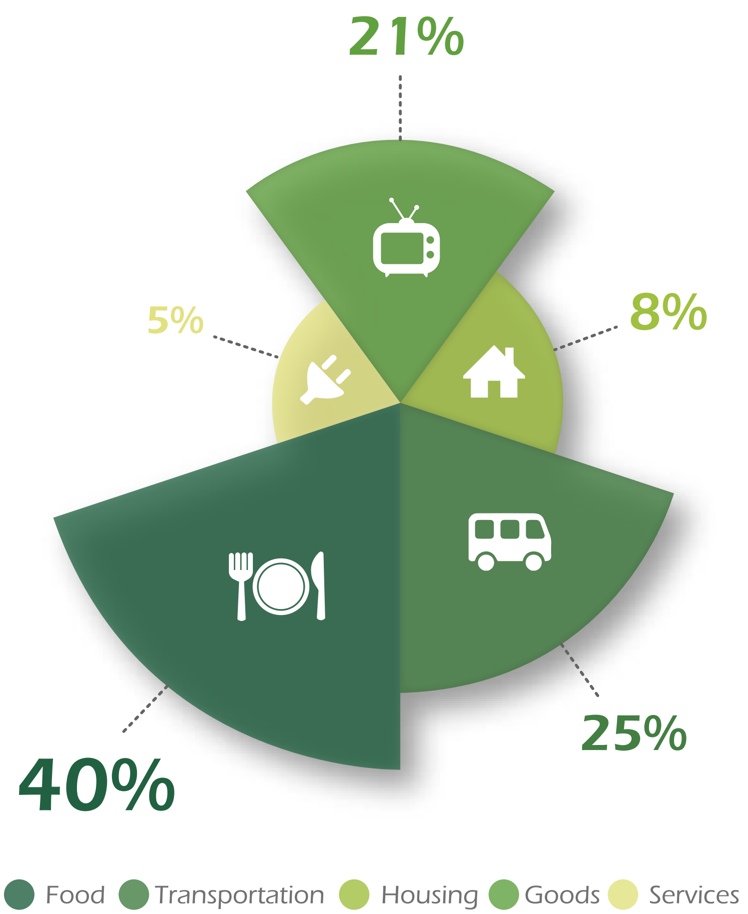
Biocapacity and ecological footprint of the MDQ:

- Ecological footprint per capita for Ecuador 2011 = 1.94 gha.
- Ecological footprint per capita for the MDQ 2011 = 1.77 gha.
- Taking into account that the biocapacity per capita for Ecuador in 2011 is 2.39 gha, the MDQ is still within the ecological limits of the country.

The largest contribution to the ecological footprint of the MDQ is household consumption (83%), followed by the formation of gross fixed capital (15%) and finally by the government (2%). *Infographic 5* shows the percentages of the domestic environmental footprint of the MDQ.

At the parish level in the MDQ, the results show that there are regional inequities. The parishes with smaller ecological footprints are rural and have values up to 35% lower than the average (Atahualpa = 35% and Nanegalito = 32%). While parishes with higher values have footprints 45% above the average (Cumbayá and Pomasqui), and achieve results which could be compared with those of developed countries.

7 Humanity's biocapacity demand is determined by adding all the demands on the productive surfaces of the planet (the area required to sustain the population): cultivated lands, grasslands, forests, fishing areas, urbanized land, and areas of forest for carbon sequestration (carbon footprint).



Infographic 5. Ecological footprint of the MDQ 2011 by household consumption

Source: Secretary of the Environment, Climatic Change Team, Ecological Footprint of the MDQ, 2014

Based on these considerations, and taking into account that the ecological footprint is a complex indicator, with several socio-environmental and economic implications, the environmental performance of this indicator is considered to be average. This current performance has generated several fields of action for involving people in reducing the ecological footprint and improving their awareness of Environmental Good Practice (EGP).

Environmental performance of the MDQ

In accordance with the sustainable city indicators, the current environmental performance in the MDQ is ranked at 'medium' level. However, beyond the district's final results for environmental sustainability, sustainable city indicators constitute an important support for identifying priority areas for intervention in environmental management and sanitation, ecosystems, integrated solid waste management, mining exploitation, adaptation to climate change, potable water and air quality.

Photo: Mauricio Mesías

Quito with a view of the Tumbaco Valley

THE STATE OF WASTE MANEGEMENT IN THE MDQ

Approximately 436,000 tons of urban solid waste is produced in Latin America. 50% of this waste is still subject to inadequate disposal and collection remains deficient in the poorer neighborhoods of metropolises (OPS, 2011).

Population growth and consumption involves the generation of waste and therefore environmental pollution impacts that require integrated management in order to protect the health of the population and preserve the environmental services provided by natural resources.

Currently, the MDQ has a coverage of 96.5% in terms of waste collection. In the next section, the value chain of integrated waste management in the MDQ is presented, containing the following components:

Generation, collection, utilization, treatment and final disposal (*Infographic 6*).

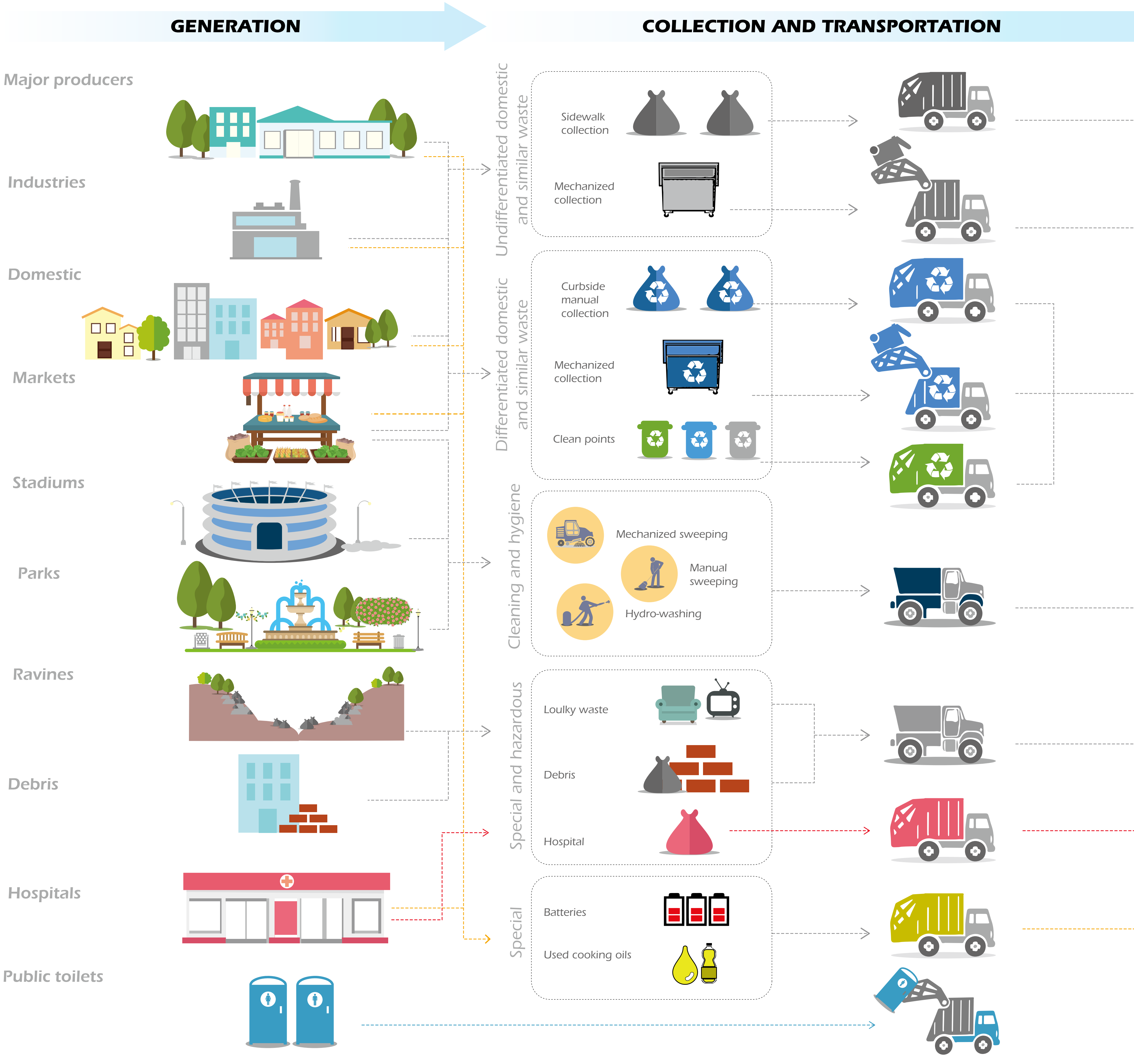
"Waste is a pressing environmental, social and economic issue. Increasing consumption and a developing economy continue to generate large amounts of waste, with mare effort required to reduce and prevent it. While waste was reviewed as disposable in the past, today it is increasingly recognized as a resource; this is reflected in the waste management shift away from dsiposal towards recycling and recovery".

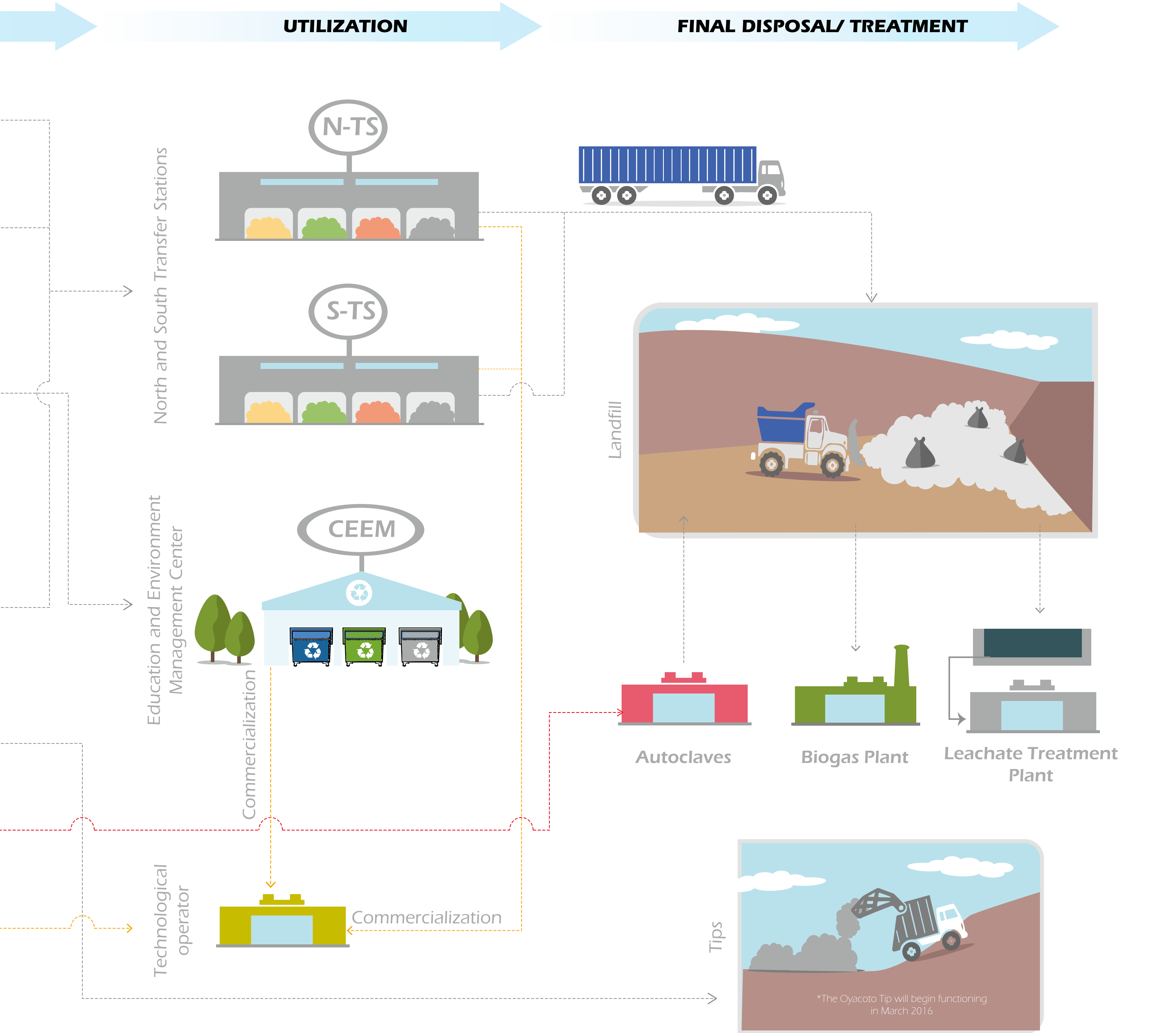
Source: European Environment Agency

Photo: Metropolitan News Agency

The Municipality's Center of Education and Environmental Management, La Delicia.

Infographic 6. The present value chain for waste management





UTILIZATION
FINAL DISPOSAL/ TREATMENT
North and South Transfer Stations
N-TS
S-TS
Education and Environment Management Center
CEEM
Commercialization
Technological operator
Commercialization
Landfill
Autoclaves
Biogas Plant
Leachate Treatment Plant
Tips
*The Oyacoto Tip will begin functioning in March 2016

Generation

In 2015, the MDQ produced an average of 2,037 tons per day of non-hazardous household and industrial waste for an urban and rural population of 2,551,721 inhabitants. Collected waste production per capita was 0.842 kg/day/person (Emaseo, 2015). In urban areas this figure was estimated at 0.879 kg/day/person and in rural areas at 0.779 kg/day/person (*Castillo/Analysis PM-GIRS*).

Figure 1 shows the growth of the Quitenian population at 2.6%/year (MTMP, 2012), while waste production per inhabitant has a negligible increase of 0.049 kg/day/person over a period of 15 years. This shows that the per capita consumption level remains constant in the MDQ.

This waste production is very similar to that in Ecuador as a whole of 0.85 kg/day/person, and also very similar to that produced in neighboring countries: in Colombia the figure is 0.85 kg/day/person, and in Peru 0.66 kg/day/person according to the *Report of the regional evaluation of municipal solid waste management in Latin America and the Caribbean 2010*, published by the Pan American Health Organization.

60% of the total waste produced in the MDQ in 2015 came from the domestic sector (*Infographic 7*).

Figure 2 shows the projection for quantities of waste generated by the different sectors of the MDQ. Waste generation in the period between 2015 and 2024 shows an increase of 350 tons/day, without considering mechanisms for the reduction of production and consumption.

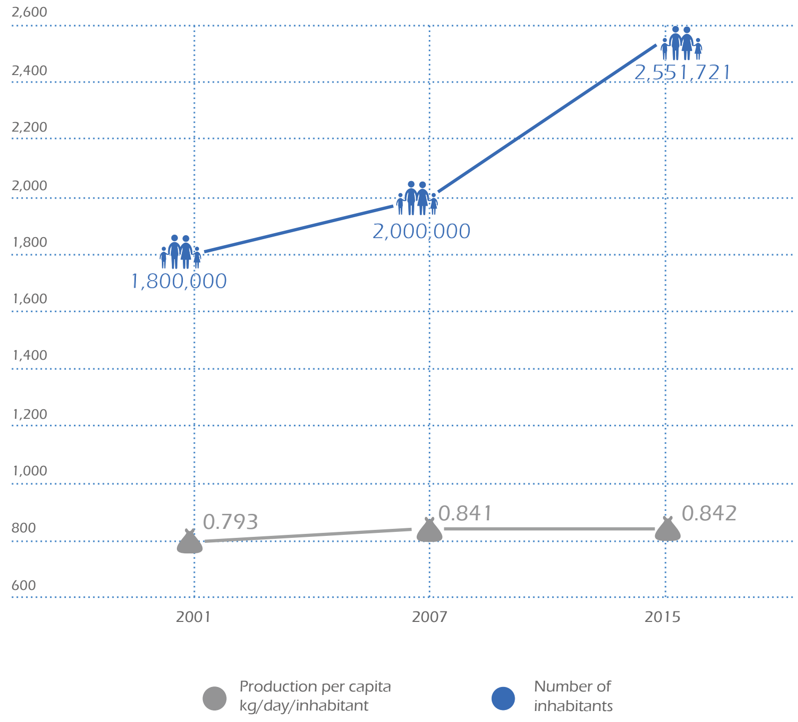
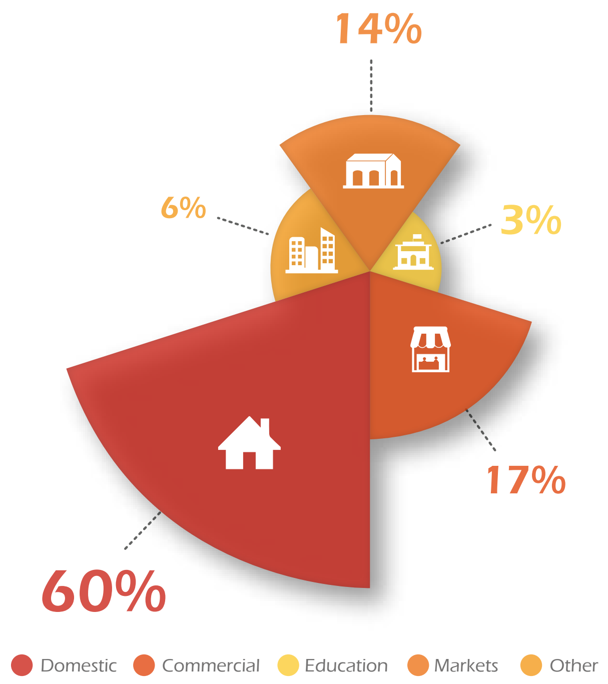
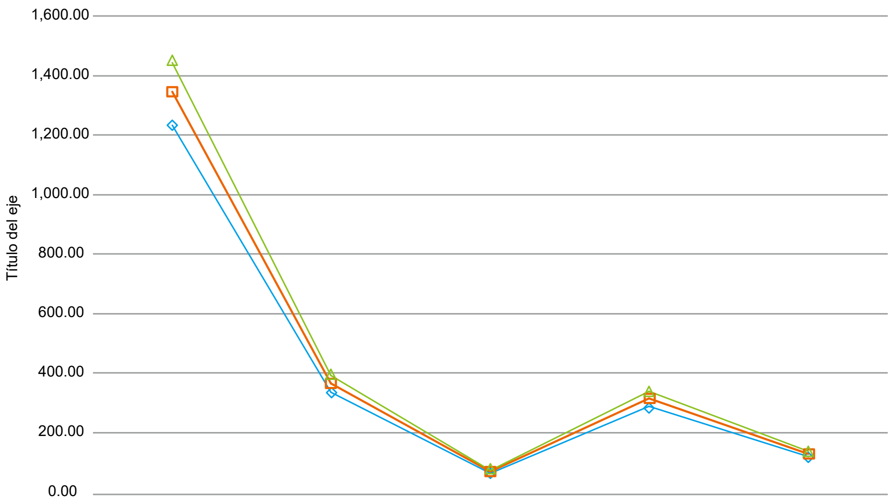


Figure 1. The growth of consumption habits in the population of the MDQ.
Source: Secretary of the Environment, Master Waste Plan, 2015.



Infographic 7. Waste production by sectors.
Source: Secretary of the Environment, Climatic Change Team, Ecological Footprint, 2014.



	DOMESTIC	COMMERCIAL	EDUCATION	MARKETS	OTHER	TOTAL
2015	1,231.64	335.71	62.67	288.33	118.62	2037
2020	1,344.57	366.49	68.42	314.77	129.49	2224
2024	1,442.32	393.14	73.39	337.65	138.91	2385

Figure 2. Projection for waste quantities generated by sectors (tons/day).
Source, Emaseo, 2015

Figure 3 shows the profile of waste delivered to the transfer stations for treatment, reuse and final disposal.

It is necessary to consider that the presence of small-scale sidewalk recycling operators holds an added value but reduces the recyclable waste registered at the transfer stations.

With regard to construction and loulky waste, debris volumes delivered to the two municipal dumps increased by 2.3 times between 2012 and 2015, reflecting a strong growth of real estate constructions (*Infographic 8*).

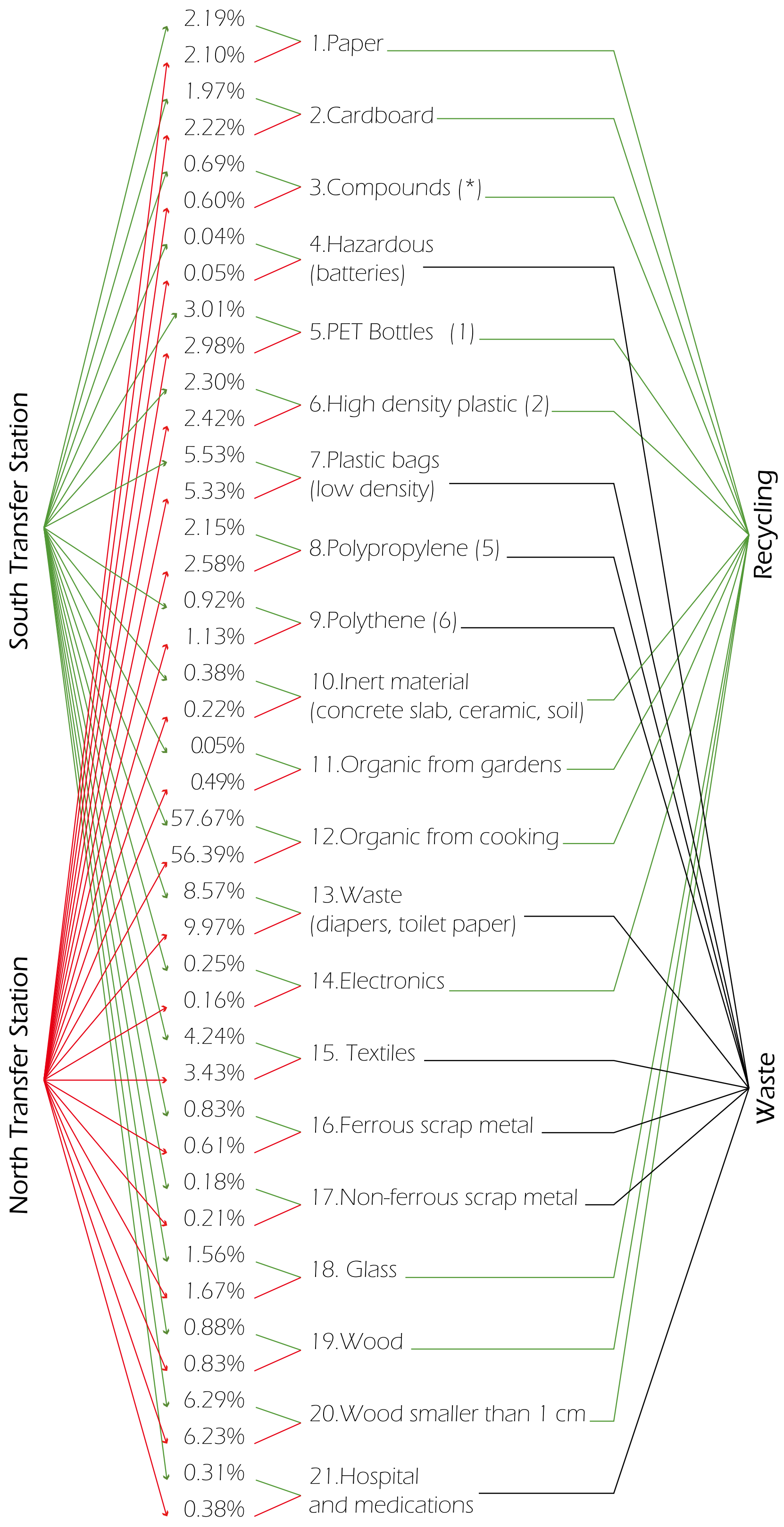
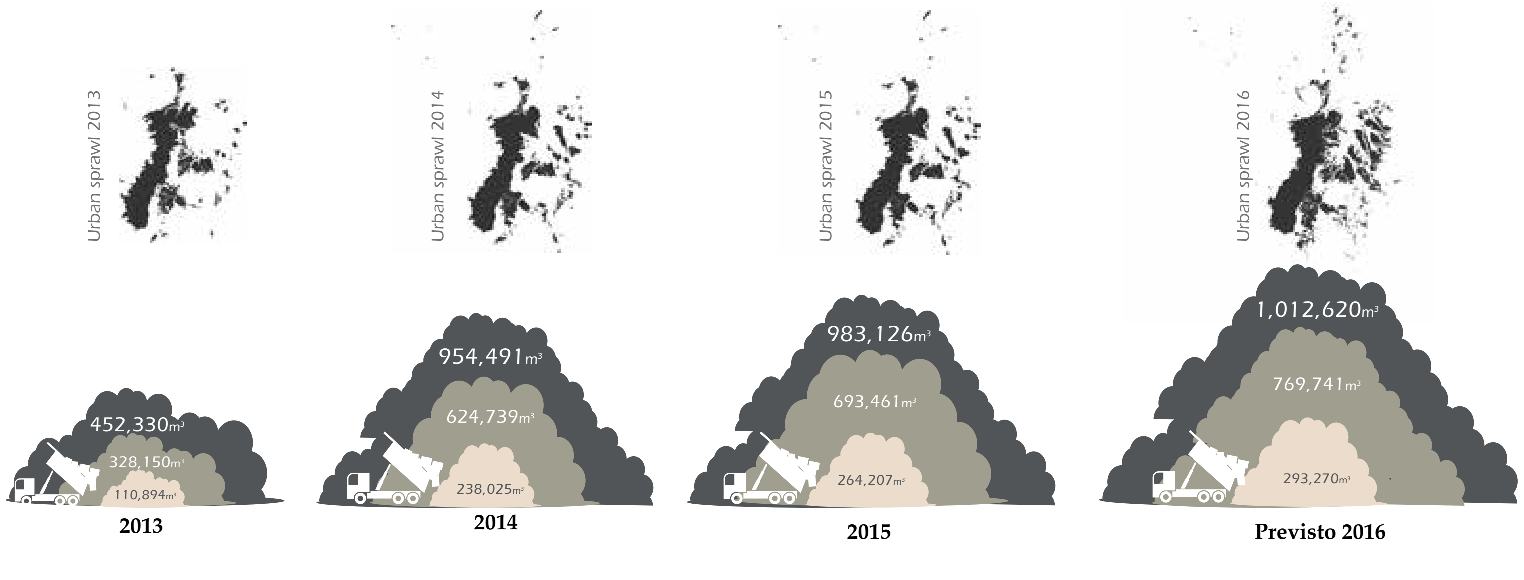


Figure 3. Profile of waste in the MDQ
Source, Emaseo, 2015



Infographic 8. Volumes delivered to the municipal tips (m³).
Source, Emaseo, 2015

Collection

In 2015 a daily average of 1,770 tons/day of MSW (Municipal Solid Waste) was collected with coverage for 96.5% of the population. By comparison, in 2007 1,677 tons/day were collected from a target population of 89%. *Infographic 9* compares waste collection between 2007 and 2015, and *Infographic 10* shows indicators for the generation and collection of waste in the MDQ.

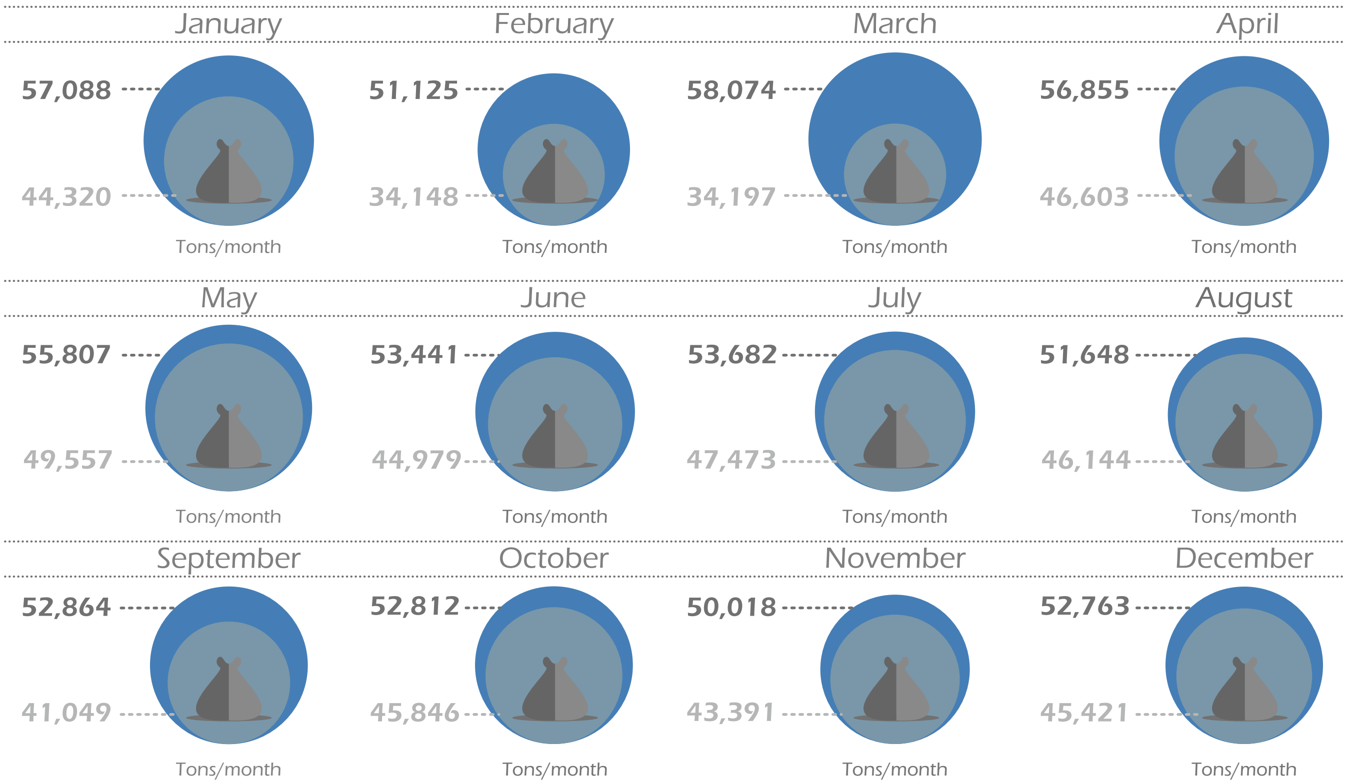
The collection operation for non-hazardous household and industrial waste is the sole responsibility of the public company Emaseo, which performs manual and mechanical collection and road sweeping activities, as shown in *Maps 1 and 2*.

The Municipal MDQ in 2015 collected a daily average of 1,700 tons of waste.

Waste collection includes the following systems:

- Curbside manual collection, in which garbage bags are used so that citizens can deposit waste on the street, this being collected by rear end garbage trucks, along with open flatbed trucks and/or front loading trucks. This system represents 69.92% of the total collection.
- Mechanized collection with containers for lateral loading or so-called ‘mechanized containerization’ are located in strategic places in neighborhoods where citizens can deposit their ‘garbage bags’. This system represents 14.95% of the total collection.
- Containers for rear loading and underground containers are available in the historic center of Quito. They represent 1.13% of the total collection.
- Major producers are large companies receiving services in the form of sidewalk collection and mechanized containerization. They represent 9.60% of the total collection.

Table 1 shows the types of collection and *Figure 4* shows the percentages of undifferentiated waste collected in 2015.

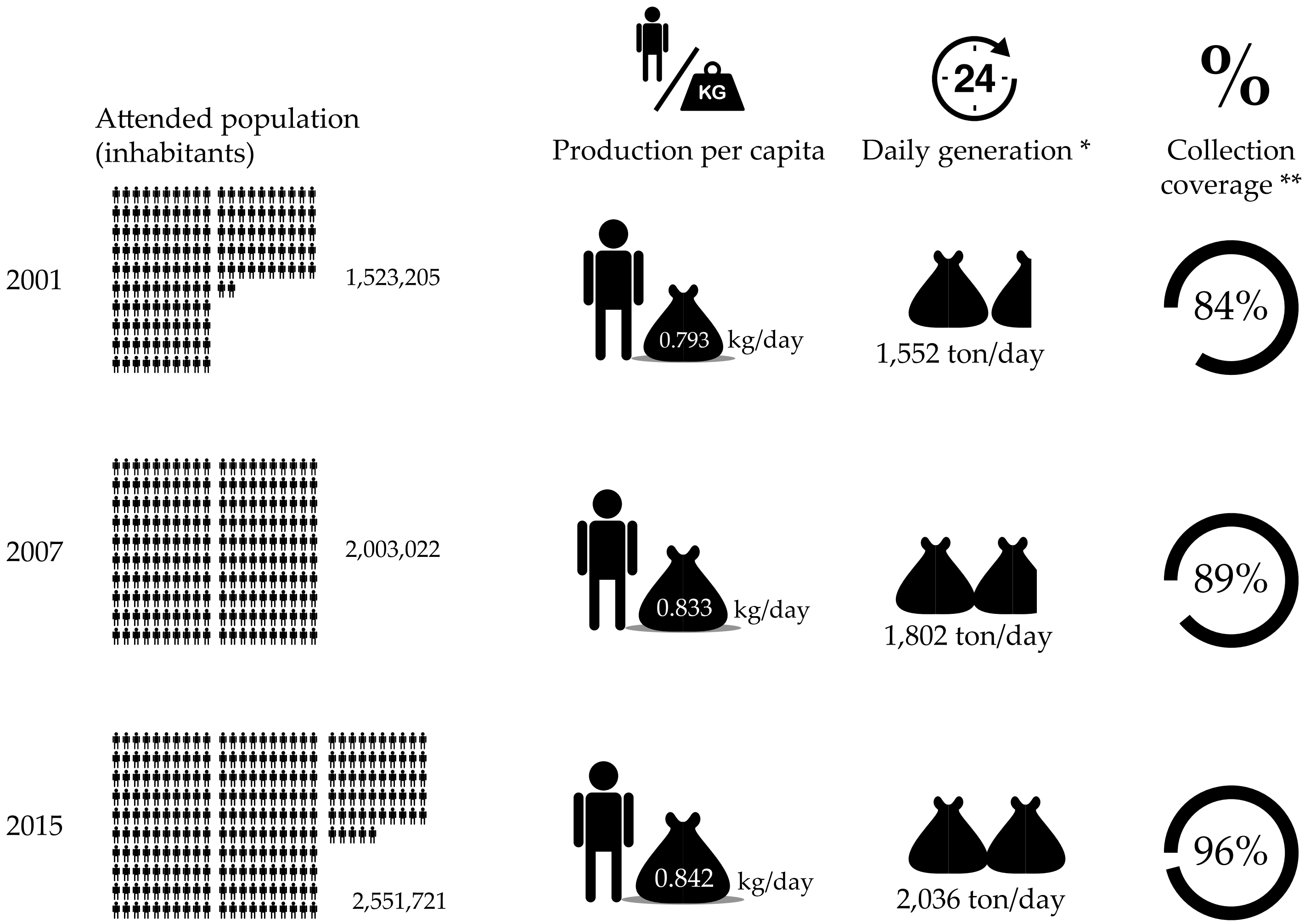


	2007	2015
Total	523,128	646,177
Average/month	43,594	53,848
Average/month	1,433	1,770

Infographic 9. Comparison of monthly waste collection in the MDQ (2007 and 2015) (tons/month)
Source, Emaseo, 2015

Mechanized collection

Photo: Metropolitan News Agency



Infographic 10. *Indicators for the generation and collection of waste in the MDQ.*
Source, Emaseo, 2015

Waste weighting in the South Transfer Station

Photo: Metropolitan News Agency

Table 1. Types of collection

2015	SIDEWALK	LARGE PRODUCERS	SURFACE MECHANIZED COLLECTION	UNDERGROUND MECHANIZED COLLECTION	CRITICAL POINTS	MANUAL SWEEPING	MECHANIZED SWEEPING	SUPPORT TO OPERATIONS	COLLECTION OF SW EMASEO-EP
JAN	39,670	5,638	6,595	665	567	1,364	75	57	54,632
FEB	34,690	5,141	6,407	343	469	1,178	87	16	48,330
MAR	40,066	5,620	7,129	643	664	1,587	123	101	55,933
APR	38,753	5,613	7,134	697	671	1,602	132	89	54,690
MAY	35,390	4,880	7,410	653	615	1,543	107	94	53,692
JUN	37,280	4,963	6,963	633	560	1,285	103	105	51,893
JUL	36,381	5,069	7,023	519	557	1,664	147	76	51,437
AUG	35,104	4,453	6,674	569	536	1,724	141	78	49,278
SEPT	36,211	4,679	6,649	568	523	1,688	181	60	50,559
OCT	35,312	4,447	7,872	547	548	1,700	153	53	50,632
NOV	30,496	4,306	9,887	578	431	1,275	139	55	47,168
DEC	30,295	4,581	12,730	603	364	1,715	114	108	50,510
TOTAL	432,648	59,389	92,474	7,019	6,506	18,325	1,501	894	618,754
PERCENTAGE	69.92%	9.60%	14.95%	1.13%	1.05%	2.96%	0.24%	0.14%	100%
AVERAGE	36,054	4,949	7,706	585	542	1,527	125	74	51,563

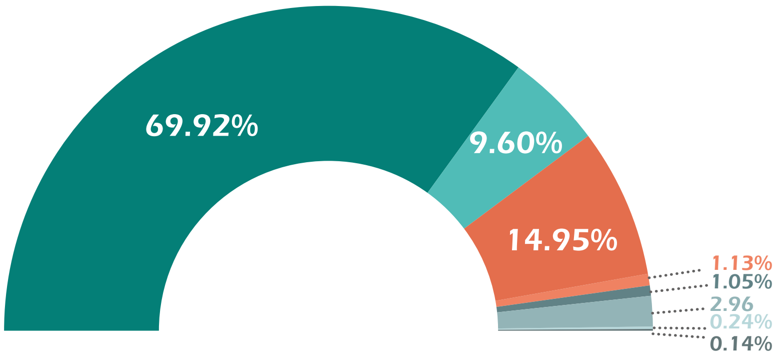
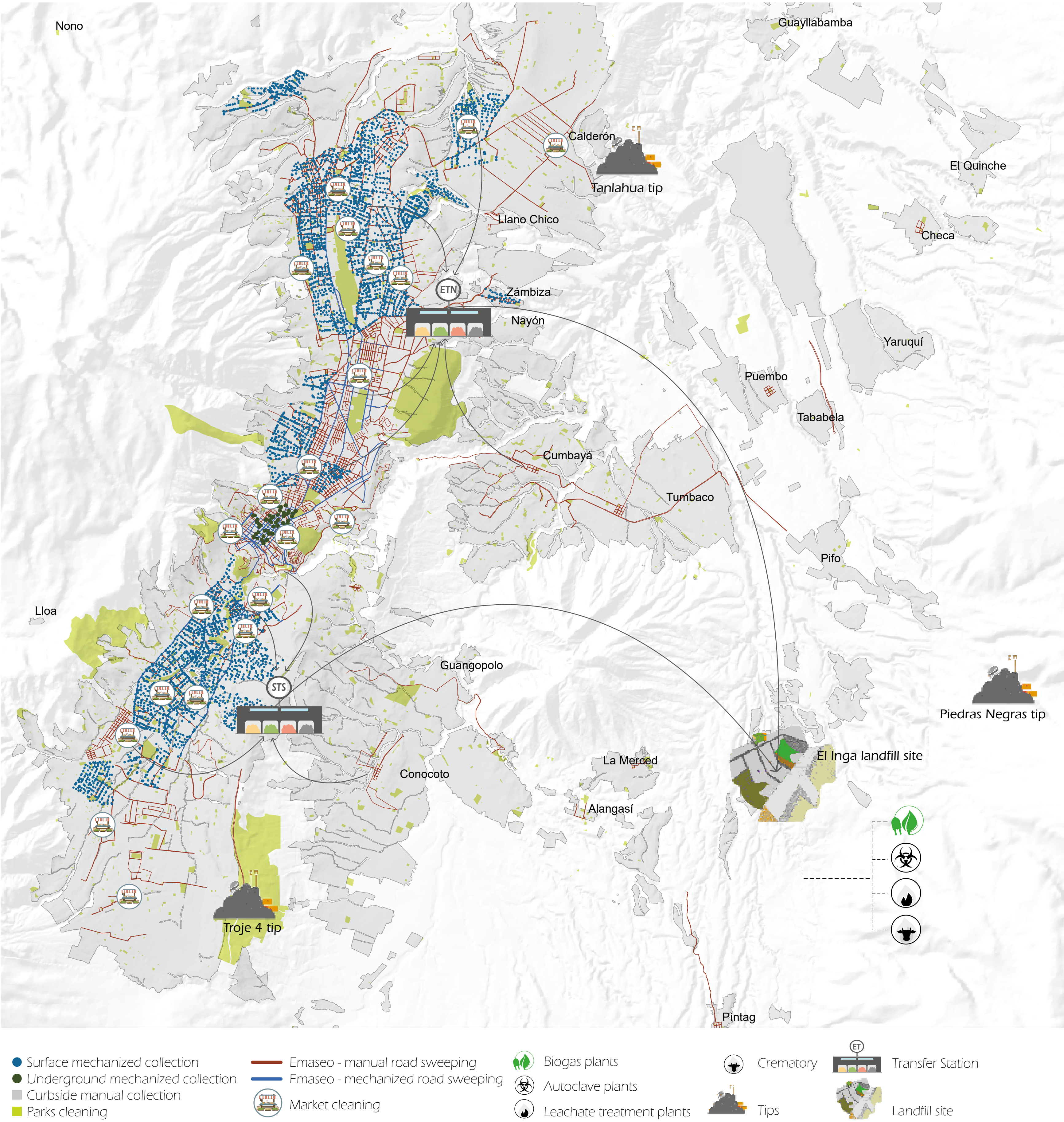


Figure 4. Percentages of undifferentiated waste collected in 2015
Source, Emaseo, 2015

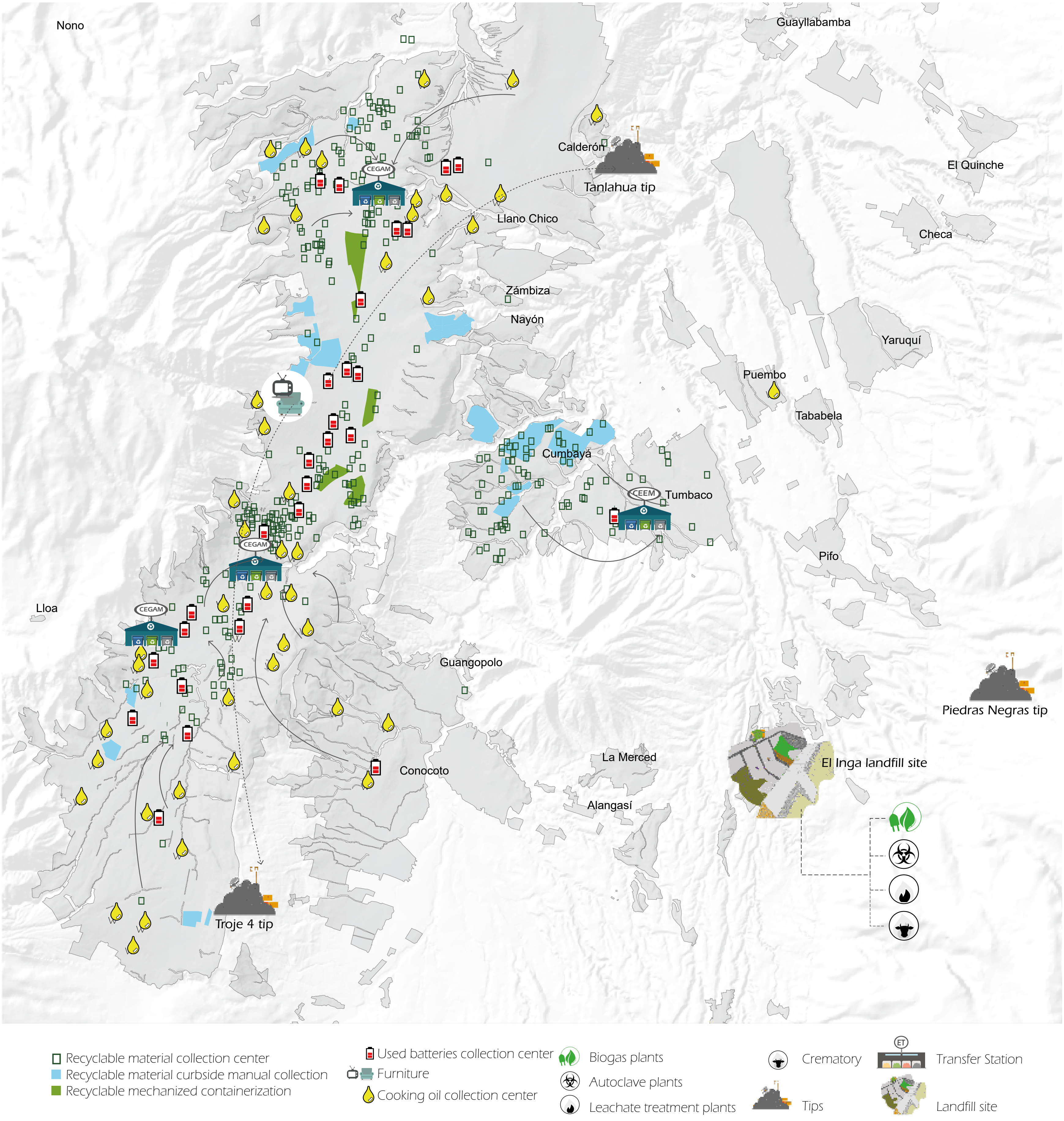
1 Map

Undifferentiated waste Collection in the MDQ



Map 2

Differentiated collection in the MDQ



Source, Emaseo, 2015

Final disposal

Since 2012, the EMGIRS-EP company has been responsible for the technical operation of the landfill at the El Inga site. There, waste disposal is performed in storage tanks from which leachates are generated that then pass through several treatments meeting the parameters required by current environmental standards, in addition to processes for the capture and use of biogas energy.

The landfill site received a daily average of 1877 tons/day in 2015 (*Figure 5*).

It should be noted that Rumiñahui parish (not in the MDQ) disposes of approximately 100 tons/day of waste at this site, giving a total waste of 685,257 tons/year.

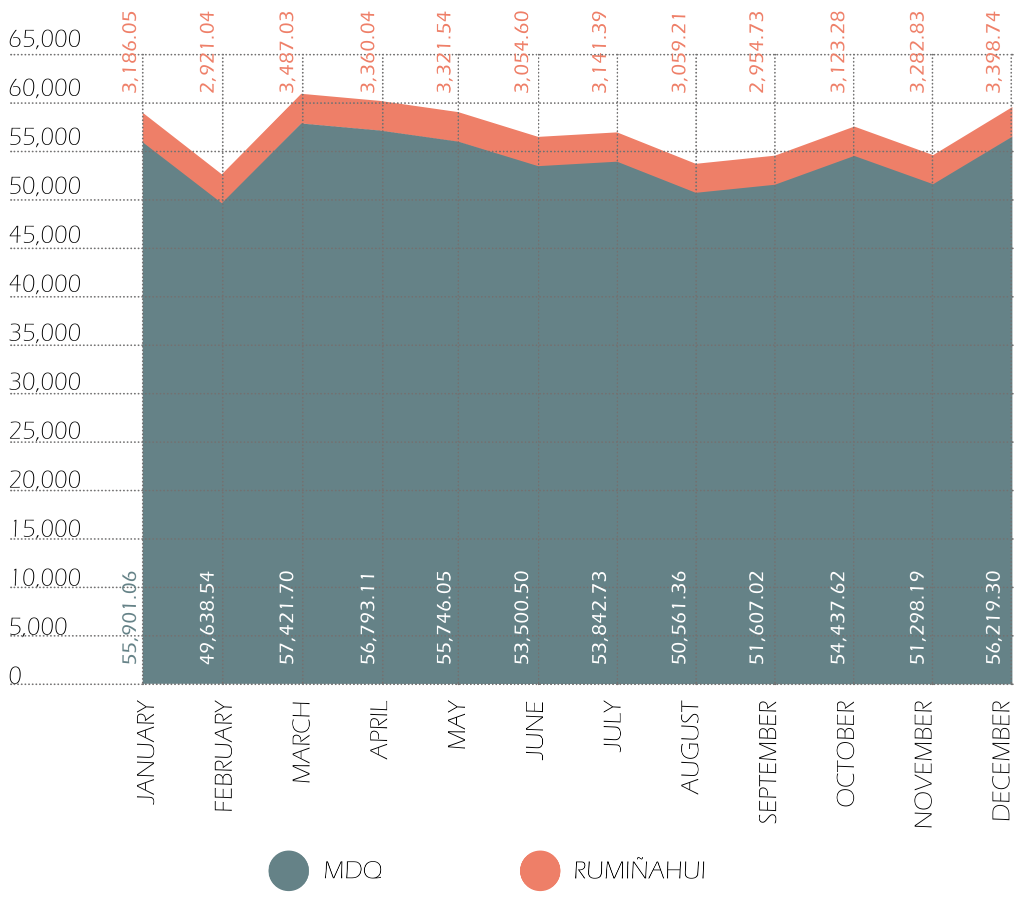


Figure 5: Solid domestic waste entry at the El Inga landfill site
Source, Emaseo, 2015

Photo: Drone & Gis

El Inga landfill site

THE STATE OF NATURAL RESOURCES

Water resources

The water quality of the rivers in Quito has been altered by the confluence of several aspects, among which are housing settlements, deposits of domestic and industrial discharges, poor disposal of garbage and debris, the existence of agricultural activity in small parcels disbursed near river banks, the natural occurrence of sediment and the sediments generated by quarrying, and the sediment also carried to rivers by the instability of the slopes bordering their channels.

Moreover, control of the discharge of wastewater in the MDQ is performed by applying Metropolitan Ordinance No. 404. This control imposes the goal that industrial sector water discharges should account for no more than 20% of the total, with the remaining 80% coming from the residential sector. In these proportions the water is delivered from the sewage system to water bodies without any pretreatment. As such, only 1% of wastewater is subjected to treatment services. This shortcoming is the subject of special attention and the planned solution is the Program of Quito River Decontamination, which aims to treat 95% of wastewater generated in the MDQ. This program is run by EPMAPS.

Photo: Germán Toaza

Huaicuyacu pond

Monitoring network

The implementation of the Metropolitan Water Resources Monitoring Network, in its initial phase, started with monitoring sites located on the San Pedro and Pita rivers as they enter the district, and on the rivers Machángara, Monjas and San Pedro after its union with the Santa Clara, these rivers have their sources and follow their courses within the territory of the MDQ and constitute the high and medium sub-basins of the Guayllabamba river. A final monitoring site is located on the Guayllabamba River as it leaves the district on the border with the province of Imbabura.

In June 2013, the monthly sampling of water began at six points on the aforementioned rivers. In situ measurements have been carried out and samples have been collected for physical chemical analysis in the laboratory of the Secretary of the Environment (*Map 3*).

Current situation

Concentrations outside the accepted ranges for oils and fats and total petroleum hydrocarbons and phenols are observed in the aforementioned rivers. The concentration of cyanide breaches the rules for conservation of flora and fauna, while the amount of Biological Oxygen Demand (BOD) does not meet the standards for human consumption. The Monjas River has the highest concentration of detergents and aluminum of the points monitored in the water network (see *Map 3*).

High concentrations of BOD in the Machángara and Monjas rivers are the result of concentrations of organic matter present in their waters, due mainly to domestic discharges entering their streams untreated. The levels of hydrocarbons are also the result of oils and fats, products of human pollution discharged into nearby drains, or the runoff of water used for cleaning in industries such as car washes and filling stations operating close to the rivers. Phenols can come from natural sources or be the result of the decomposition process of organic matter.

Finally, from the analyses performed and their comparison with standards and the uses of water resources, it is concluded that the waters of the Machángara and Monjas rivers receive discharges of untreated sewage directly into their channels, for which reason they should not be used for irrigation or agriculture.

Quitenian Water Resource Index

The simplified Quitenian Index of the Quality of Water Resources applied to data from the Quito Water Network, is calculated by taking into account the values for temperature, dissolved suspended solids, conductivity, COD (Chemical Oxygen Demand) and dissolved oxygen. The classification provided is as follows: black water with fermentation and smell = 0-25. Appearance of contaminated waters and strong smell = 25-50. Lightly colored water, with foam and light water turbidity, unnatural = 50-75. Clear water with no apparent contamination = 75-100 (Queralt, R.R., 1982: 4) (*Figure 6*).

The overall analysis of the quality of water resources during 2015 shows us that, of the rivers analyzed, the simplified quality index indicates waters of ‘contaminated appearance’ and ‘strong odor’ for the Machángara and Monjas rivers, and ‘light water color, with light foam and water turbidity, unnatural’ for the San Pedro and Guayllabamba rivers within the Metropolitan District of Quito. Only the Pita River is in the category of ‘clear water with no apparent contamination’. This poor condition of water resources is due to a lack of sewage collectors and the lack of plants for the treatment of sewage in the Metropolitan District of Quito.

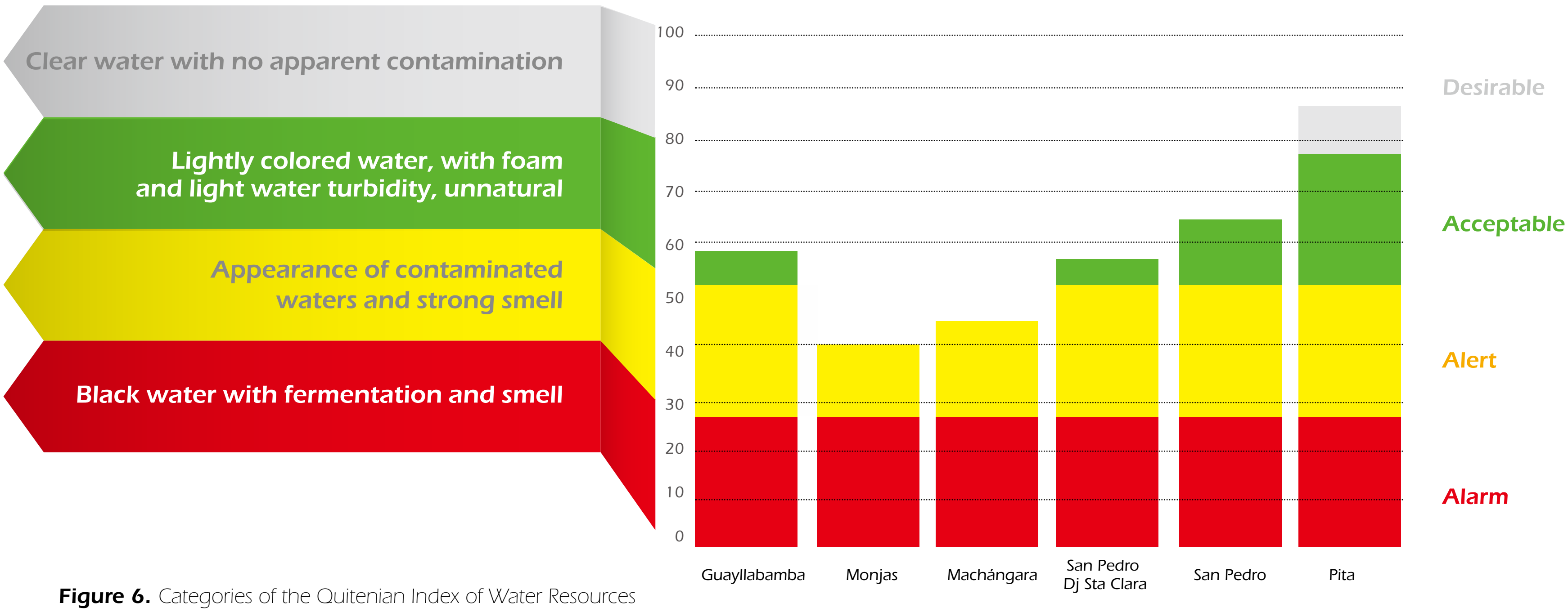


Figure 6. Categories of the Quitenian Index of Water Resources
Source: Secretary of the Environment, Research, Analysis and Monitoring Unit, 2015

Water footprint in the MDQ

The Water Footprint (WF) can be understood as an indicator that reflects the direct and indirect use, consumption and pollution of water. The information displayed in the WF permits the analysis of the environmental, social and economic implications of the use of water in different geographical areas.

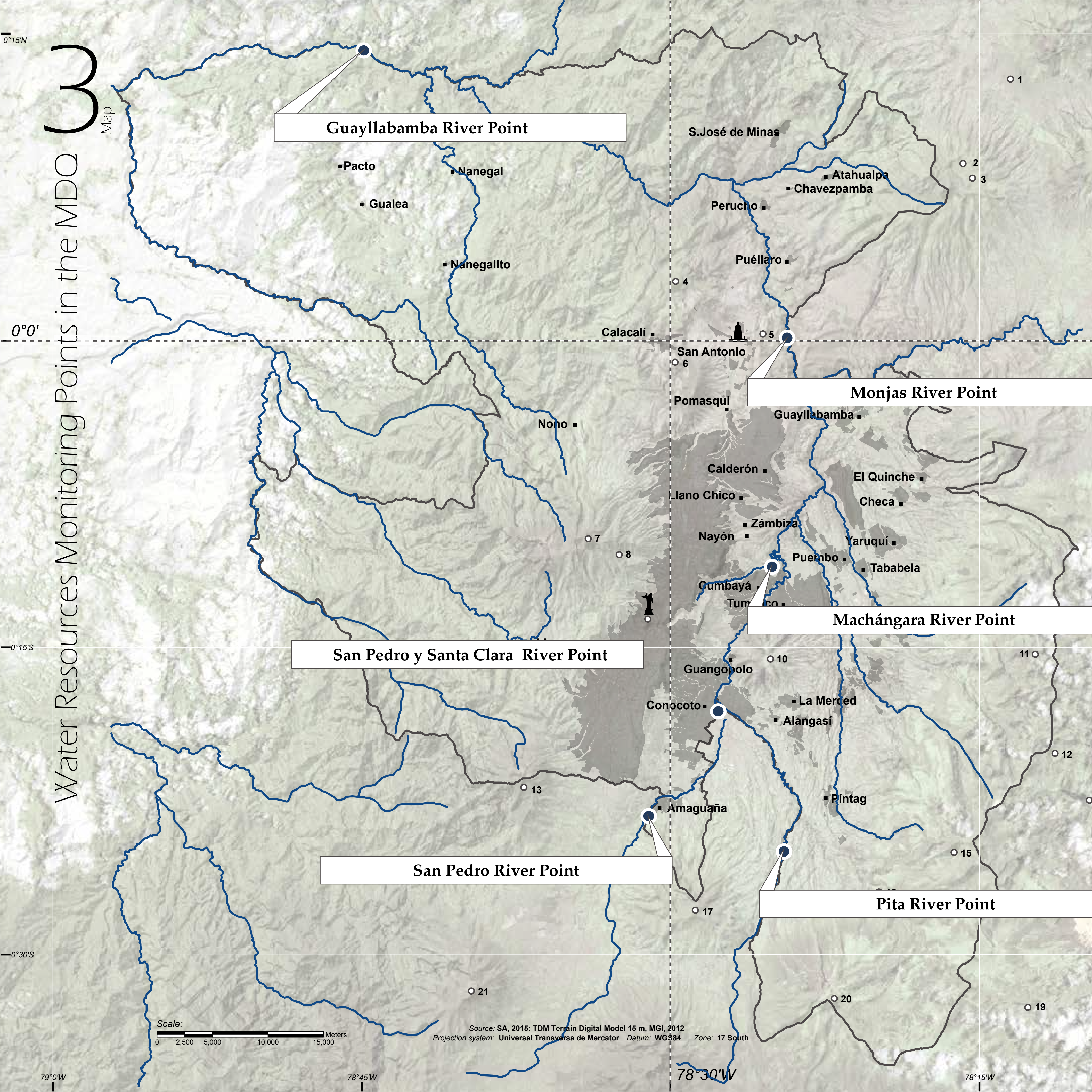
The water footprint can be quantified in terms of:

- The volume of water that is used in a consumptive manner, i.e. evaporated or incorporated into a product and not returned to the basin, which is known as blue WF.
- The volume of water required to assimilate the pollution load of effluents, called gray WF.
- The volume of rainwater used by vegetation, known as green WF.

The total water footprint of the MDQ was 1,027,695,152 m^3 for 2011, equivalent to the volume of water that, hypothetically, more than 17 million Quitenians would consume in one year (actual 2011 population = 2.2 million).

The main contributor to the total direct WF of the MDQ is the residential sector, followed by the commercial sector, public/municipal services and finally, industry. This would firstly suggest the need for the residential sector to receive priority attention, especially its gray WF, which alone accounts for 84% of total direct WF of the MDQ. *Infographic 11* shows the values of the total direct WF of the MDQ.

The WF of the MDQ is directly related to the water quality of the rivers of the MDQ. It suffers from a process of deterioration mainly because a service of wastewater treatment is not available and only 1% of wastewater is treated by the Metropolitan Public Company of Potable Water and Sanitation (EPMAPS).


3
Map
Water Resources Monitoring Points in the MDQ
0°15'N
0°0'
0°15'S
0°30'S
79°0'W
78°45'W
78°30'W
78°15'W
Guayllabamba River Point
Monjas River Point
Machángara River Point
San Pedro y Santa Clara River Point
San Pedro River Point
Pita River Point
S.José de Minas
Atahualpa
Chavezpamba
Perucho
Puéllaro
Pacto
Nanegal
Gualea
Nanegalito
Calacalí
San Antonio
Pomasqui
Guayllabamba
Nono
Calderón
Llano Chico
El Quinche
Checa
Zámbiza
Nayón
Yaruquí
Puembo
Tababela
Cumbayá
Guangopolo
Conocoto
La Merced
Alangasí
Amaguaña
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Scale:
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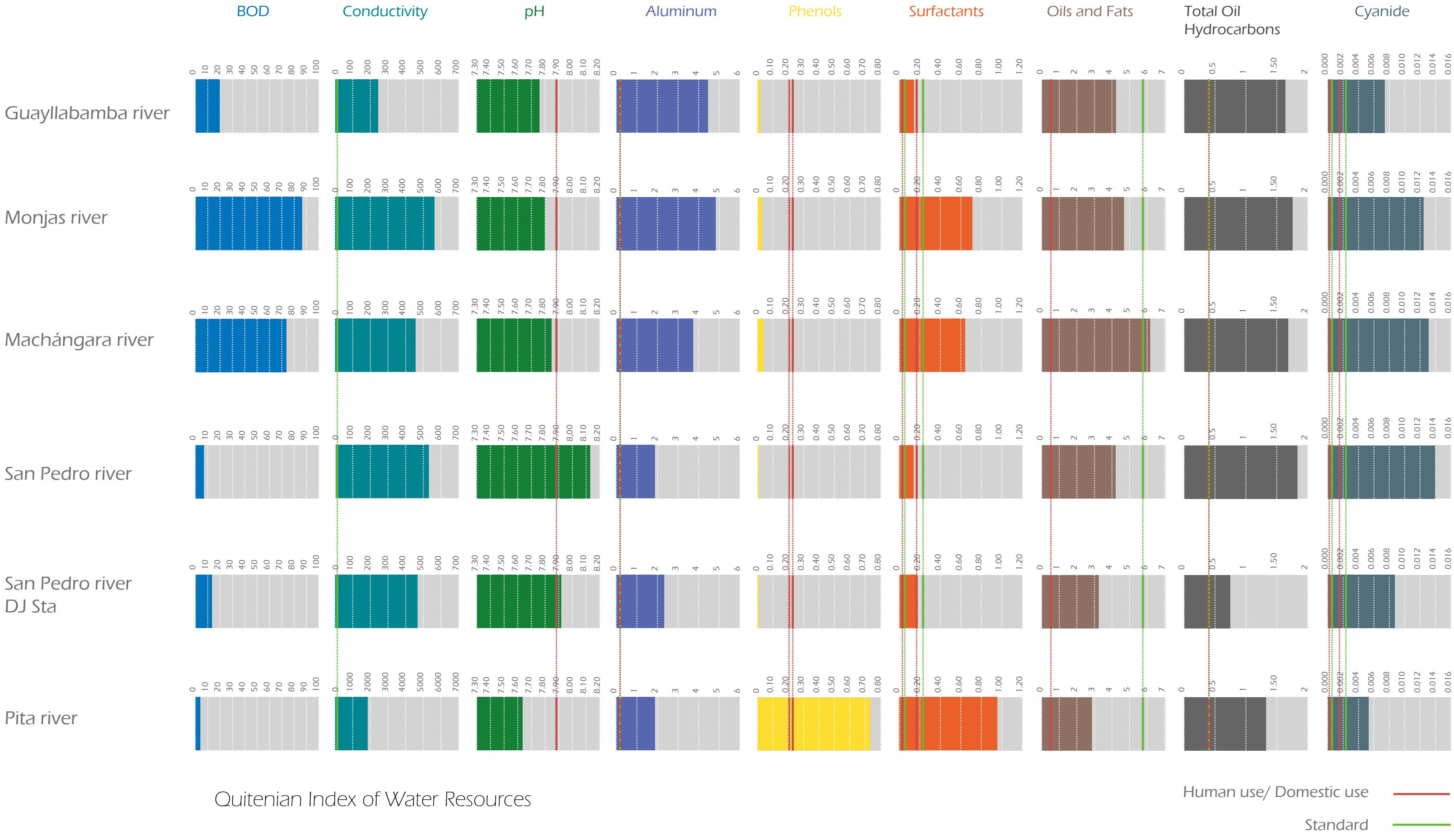
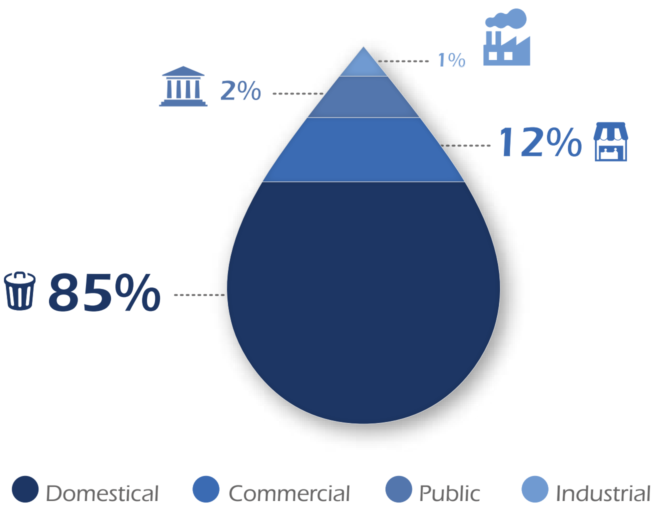
Source: SA, 2015: TDM Terrain Digital Model 15 m, MGI, 2012
Projection system: Universal Transversa de Mercator Datum: WGS84 Zone: 17 South



Quitenian Index of Water Resources



Infographic 11. Water Footprint Components.
Source: Secretary of the Environment, Climatic Change Team, 2014

Air quality

Environmental pollution has negative consequences on the inhabitants life quality of the urban centers it affects. This contamination can cause, aggravate or exacerbate episodes of respiratory and cardiovascular diseases and reduce life expectancy. Symptoms include dizziness, nausea, headaches, eye irritation, breathing difficulties, and others. The elderly, children and people with asthma, cardiovascular problems or diabetes are among the groups vulnerable to environmental pollution. These negative health effects are produced both by short term exposure to high concentrations and long term exposure to low concentrations.

According to the latest emissions inventory developed for the Metropolitan District of Quito (2011), traffic is responsible for 95% of polluting emissions of carbon monoxide into the atmosphere.

Vehicular traffic, industry and power plants are the major emitters of particulate matter. However, mining, transportation of building materials, roads without asphalt coating and agriculture also contribute to the increase of this pollutant.

Air quality in the Metropolitan District of Quito has remained under acceptable conditions in recent years, with improvements in some areas compared to the early years of monitoring due to the implementation of policies with this goal. However, the impact of these policies has not been sufficient to achieve effects in reducing fine particle pollutants, which exceed the annual national standard on a recurring basis. It should be noted that this is a worldwide phenomenon.

Panoramic view of the Volcano Pichincha

In addition, public perception about air quality remains negative in the MDQ.

The data generated by Quito's Metropolitan Environmental Monitoring Network proved low fuel quality and led to demands for improvement. Thus, from 2005 only premium diesel has been distributed in the Metropolitan District of Quito, this fuel had sulfur concentrations 14 times lower than the fuel traded in the rest of the country. Only since 2011 has fuel improved on a nationwide basis.

In May 2010 the 'peak and plate' (restriction of the circulation of vehicles according to their number plates at peak hours) traffic control measure was implemented in order to expedite vehicular traffic. This has had positive effects in reducing the exposure of pedestrians and drivers in the peak pollution hours of the morning and late afternoon. Concentrations of vehicular traffic at peak hours have decreased by 20% in sectors where the measure is applied.

Similarly, in 2015 the random control of public service vehicles on the roads of the city was resumed.

Air monitoring network

The Air Monitoring Network (see monitoring points, *Map 4*) became fully operative in the middle of 2003 and has provided valid information by means of procedural and documentary support since January 2004.

The location of the monitoring stations complies with the recommendations of the Environmental Protection Agency of the United States (US-EPA) (EPA. 40CFR58, Appendix E) and the World Meteorological Organization (WMO No. 8).

The network includes six complementary subsystems that record the concentration of air pollutants, the main meteorological variables and environmental noise.

The Quitenian Metropolitan Air Quality Monitoring Network monitors continuously, 24 hours a day, 365

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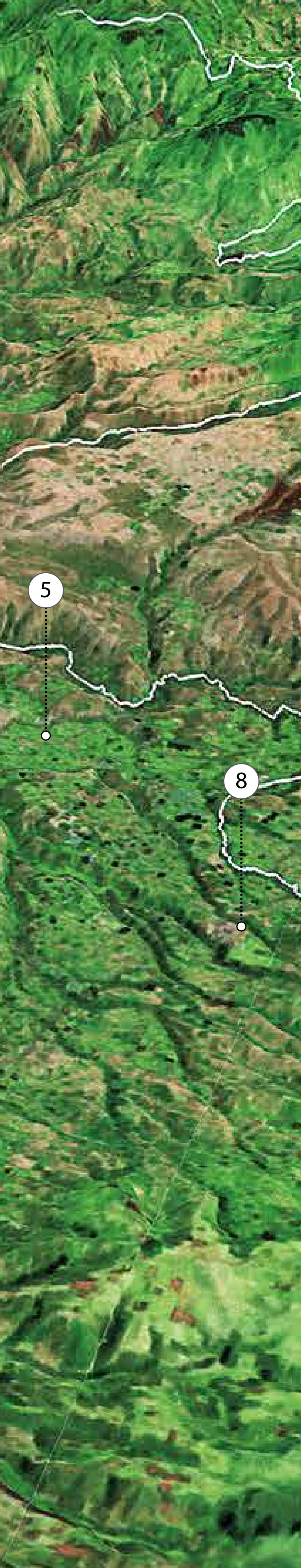


Map 4

Air monitoring points in the MDQ

Type	Number	Monitoring Station	SO_2	NO_2	O_3	CO	PM_{10}	NOx	$PM_{2.5}$	BTX	Aldehydes	SM	Meteorology
Manual	1	Nanegalito	x	x	x							x	
	2	Nono	x	x								x	
	3	San Antonio de Pichincha	x	x	x							x	
	4	Pomasqui	x	x	x							x	
	5	Guayllabamba	x	x	x							x	
	6	La Roldós	x	x	x							x	
	7	Calderón	x	x	x							x	
	8	El Quinche	x	x	x								
	9	Parque de los Recuerdos	x	x	x								
	10	Kennedy	x	x								x	
	11	Jipijapa	x	x	x		x					x	
	12	Monteserrín	x	x								x	
	13	Cruz Loma	x	x	x								
	14	Bellavista	x	x								x	
	15	Tababela	x	x	x							x	
	16	Cumbayá	x	x	x							x	
	17	Seminario Mayor	x	x	x								
	18	González Suárez	x	x	x							x	
	19	La Mariscal	x	x	x								
	20	El Guambra	x	x	x								
	21	San Juan	x	x	x							x	
	22	Maternidad	x	x	x								
	23	Itchimbía	x	x	x							x	
	24	Basílica	x	x	x								
	25	San Roque	x	x	x								
	26	La Marín	x	x	x								
	27	Necochea	x	x	x								
	28	Lloa	x	x	x								
	29	Chilibulo	x	x	x							x	
	30	La Argelia										x	
	31	Chillogallo	x	x	x							x	
	32	Guajaló	x	x	x							x	
	33	Conotoco	x	x	x							x	
	34	Píntag	x	x	x							x	
	35	Quitumbe										x	
	36	La Ecuatoriana	x	x	x							x	
	37	Amaguaña	x	x	x							x	
Automatic	38	Carapungo	x		x	x	x	x	x			x	x
	39	Cotocollao	x		x	x	x	x	x			x	x
	40	Tumbaco	x		x	x	x	x	x			x	x
	41	Belisario	x		x	x	x	x	x			x	
	42	Centro	x	x	x					x	x	x	
	43	Los Chillos	x		x	x	x	x	x			x	x
	44	Guamaní	x		x	x	x	x	x			x	

Source: Secretary of the Environment, Research, Analysis and Monitoring Unit, 2015.

days a year, in various sectors of the Metropolitan District of Quito (see *Map 4*).

The data generated by this network are publicly accessible and are stored in the institutional website www.quitoambiente.gob.ec, showing concentration values and data expressed in terms relating to the Quitenian Index of Air Quality.

Quitenian Index of Air Quality, QIAQ

The QIAQ is a numerical scale from 0 to 500, with intermediate ranges displayed in different colors, to which the measured concentrations of pollutants are converted. The higher the value on the QIAQ the greater the level of air pollution, and consequently, the greater the danger to people's health.

The QIAQ assigns a value of 100 to the maximum allowable limit in the national air quality standard for each different pollutant. QIAQ values between 0 and 100 imply that the measured concentrations are below the maximum allowable limits.

Below this basic consideration there are six defined levels or categories, the upper limits for each category relating to the following criteria:

- The first two categories, desirable or optimal and acceptable or good, correspond to the values of 50% (half) and 100% (totality) of the maximum limit established by the Ecuadorian Air Quality Standard (EAQS), for the measurement periods used in defining alert, alarm and emergency levels in the same standard (Quitenian Index of Air Quality, Corpaire, 2004).
- The (optimal) desirable level is an indication of the best achievable condition, and thus encourages compliance with regular or normal control measures defined by the authorities and society as a whole. The acceptable level (good) indicates compliance with the quality standard.
- Between the maximum allowable limit (according to the standard) and the alert level, a precautionary level has been introduced, which while not indicating the occurrence of a critical episode of pollution (Quitenian Index of Air Quality, Corpaire, 2004), does indicate an exceedance of limits that must be reported.
- For the three categories of alert, alarm and emergency the values set in the Environmental Air Quality Standard concentrations correspond to the concentrations necessary for defining levels of alert, alarm and emergency in response to critical air pollution episodes.

Figure 7 presents the categories of the QIAQ and their limit values for each common pollutant of the atmosphere, along with the color code relevant to each category.

Infographic 12 displays the different affects suffered by 'sensitive individuals' from atmospheric pollutants. This information has been developed from research conducted by the Environmental Protection Agency of the United States.

Current air quality situation in the MDQ

Air Quality in the Metropolitan District of Quito is influenced by the weather, topography and various other natural factors and anthropogenic sources.

There have been several interventions to control growing environmental pollution; however, no action is sufficient without the participation of citizens who should be conscious of their responsibilities.

Consolidation of the Vehicular Technical Review, which began in 2000, has allowed the control of gas emissions, the improvement of vehicle maintenance, and in some cases, migration to newer technologies producing smaller amounts of gas. In this manner,

Range		Category	CO	O_3	NO_2	SO_2	$PM_{2.5}$	PM_{10}
0 a 50	01	Desirable Level	0 - 5000	0 - 50	0 - 100	0 - 62,5	0 - 25	0 - 50
51 a 100	02	Acceptable Level	5001 - 10000	51 - 100	101 - 200	63,5 - 125	25,5 - 50	51 - 100
101 a 200	03	Concern Level	10001 - 15000	101 - 200	201 - 1000	126 - 200	51 - 150	101 - 250
201 a 300	04	Alert Level	15001 - 30000	201 - 400	1001 - 2000	201 - 1000	151 - 250	251 - 400
301 a 400	03	Alarm Level	30001 - 40000	401 - 600	2001 - 3000	1001 - 1800	251 - 350	401 - 500
401 a 500	04	Emergency Level	> 40000	> 600	> 3000	> 1800	> 350	> 500

Figure 7. Concentration ranges (ug/m³) and their QIAQ correlation.
Source: Quitenian Index of Air Quality, 2004

emissions of carbon monoxide from gasoline cars have been reduced to 'desirable' levels and control has been exerted over increases in particulate matter $PM_{2.5}$.

The Retrofit project began in 2005, and consisted of fitting the city's Ecovia buses with particulate reduction devices. The project decreased emissions from this bus type by approximately 50%.

The 'peak and plate' initiative for restricting vehicular movement began in 2010, although this is not a measure for environmental control, it has caused a decrease in pollution during peak hours.

Recently, controls of public bus services performed on the city's roads have restarted. This action has been very effective and during 2015 there was a decrease in fine particulate matter ($PM_{2.5}$) during peak traffic circulation hours.

Following is an analysis of air quality conditions in the MDQ compared with national standards and the health effects caused by poor air quality.

Table 2 shows the sources from which settable material comes and the maximum values reached in the MDQ.

Figure 8 and *Map 5* indicate the effects of sediment material on health, as well as trends of this pollutant over the 2006-2014 monitoring period in the critical monitoring stations. At all these stations, downward trends in the last two years are observed, except for San Antonio de Pichincha. These decreases are mainly due to improvements in each sector, such as the paving of streets and the completion of road construction.

Map 5 shows the distribution of contaminants in the Metropolitan District of Quito and the evolution

Ozone

Children who spend time outside, adults who do significant physical activity outside and individuals with respiratory diseases such as asthma.

Sediment Material

People who have lung or heart diseases, such as asthma, chronic obstructive pulmonary disease, heart congestion or similar. Children, seniors, and pregnant women.

Carbon Monoxide

People with cardiovascular diseases, such as angina or those diseases that affect the cardiovascular and respiratory systems (for example congestive heart failure, cerebrovascular diseases, anemia, chronic pulmonary obstruction), pregnant women, unborn and newborn babies.

Sulfur Dioxide

Children, adults with asthma or other chronic respiratory diseases, and people who perform physical activities outside.

Nitrogen Dioxide

Children and adults with respiratory diseases such as asthma.

Infographic 12. Identification of sensitive individuals according to types of air contamination
Source: Elaborated by Investigation, Analysis and Monitoring Unit Quito (IAMQ), 2010

SM Sediment Material

	Value	Period
Ecuadorian Standard	1 mg/cm²	30 days
WHO guideline		
Maximum value (2005-2014)	3.2 mg/cm² year 2012 Quitumbe	30 days
Critical stations	San Antonio de Pichincha, Guajaló, Tababela and Quitumbe	

Table 2. Sediment material
Elaborated by IAMQ, 2016

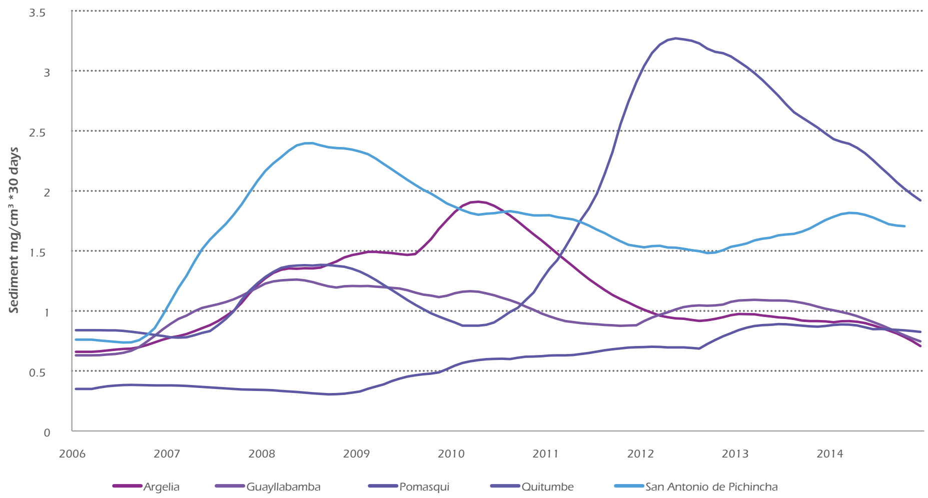


Figure 8. Sediment material tendencies (mg/m3) 2004-2014, maximum 8-hour average.

Health effects: Continued exposure to high concentrations causes irritation to the throat and mucus membrane.
Pollution sources: Wind erosion and unpaved traffic roads.

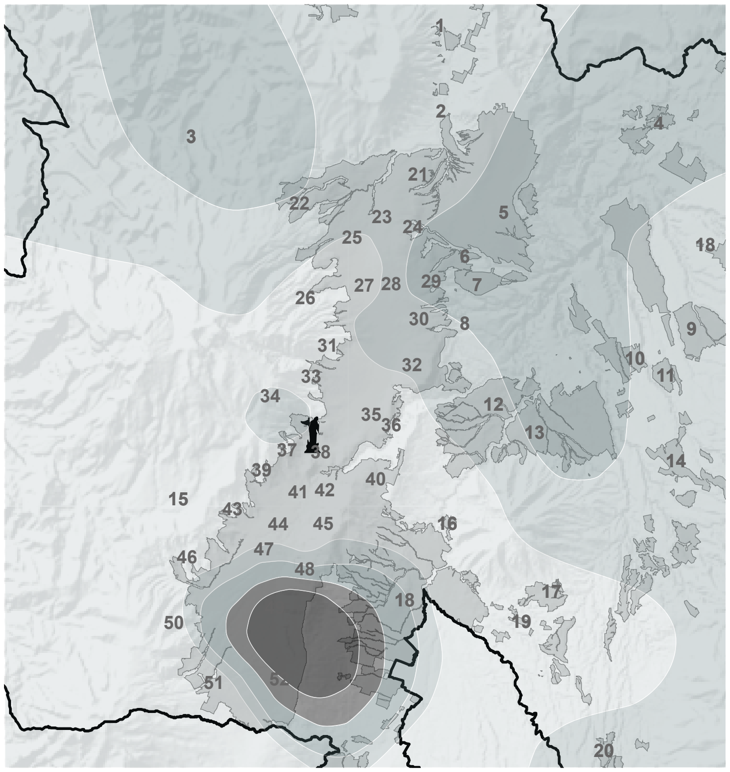
Elaborated by IAMQ, 2016

5 Map

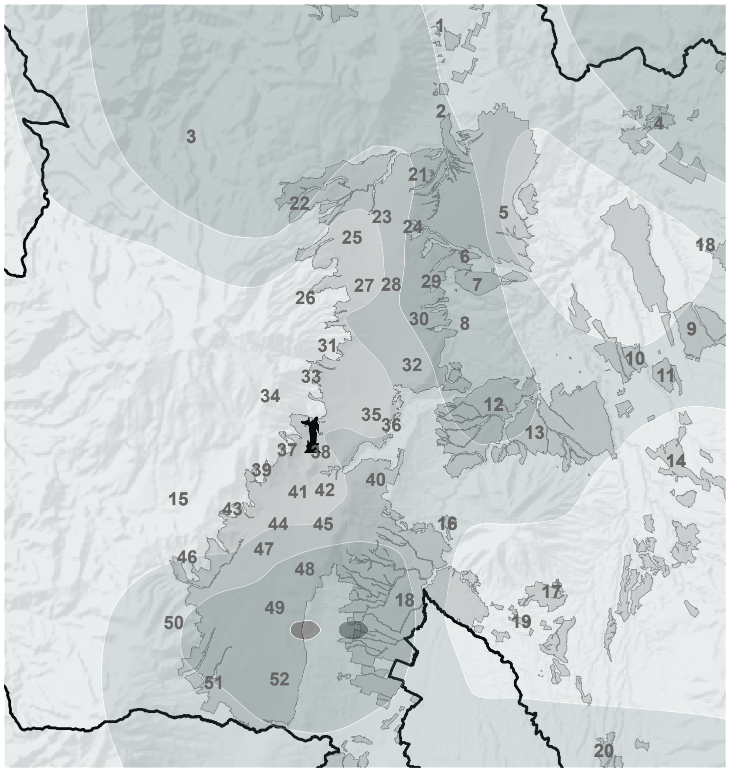
Contamination trends of SM

SM

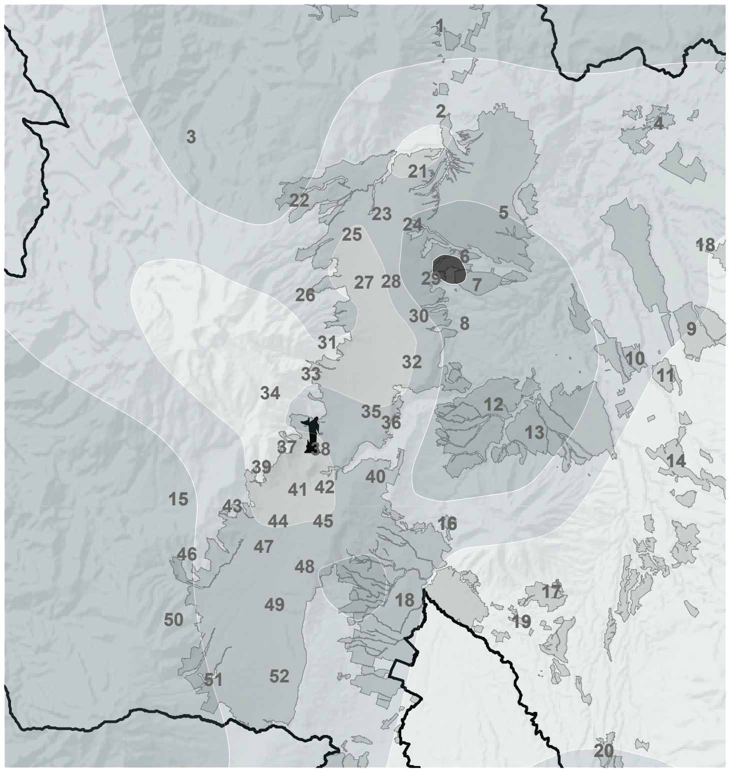
Year 2011



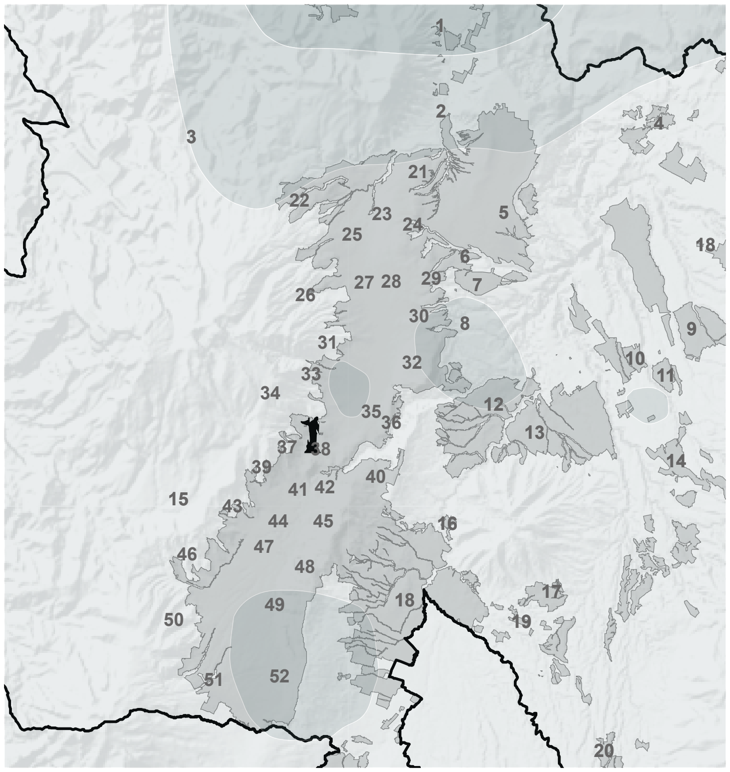
Year 2012

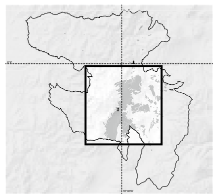


Year 2013



Year 2014





Deposit mg/cm^2

- Less than -0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4

1 San Antonio
2 Pomasqui
3 Nono
4 Guayllabamba
5 Calderón
6 Llano Chico
7 Zámbiza
8 Nayón
9 Yaruquí
10 Puembo
11 Tababela
12 Cumbayá
13 Tumbaco
14 Pifo
15 Lloa
16 Guangopolo
17 La Merced
18 Conocoto
19 Alangasí
20 Píntag
21 Carcelén
22 Condado
23 Ponceano
24 Comité del Pueblo
25 Cotocollao
26 Cochapamba
27 Concepción
28 Kennedy
29 San Isidro del Inca
30 Jipijapa
31 Rumipamba
32 Iñaquito
33 Belisario Quevedo
34 San Juan
35 Mariscal Sucre
36 Itchimbía
37 La Libertad
38 Centro Histórico
39 Chilibulo
40 Puengasí
41 La Magdalena
42 Chimbacalle
43 La Mena
44 San Bartolo
45 La Ferroviaria
46 Chillogallo
47 Solanda
48 La Argelia
49 Quitumbe
50 La Ecuatoriana
51 Guamaní
52 Turubamba

of this distribution during the years 2011, 2012, 2013 and 2014. This set of maps shows a significant decrease in sediment material throughout the Metropolitan District of Quito, especially in the southern neighborhoods of Quitumbe and Argelia in which road paving works were performed. Similarly, in the area of Cumbayá and Tumbaco the construction of the Ruta Viva highway, which contributed to an increase of material in these sectors during the years 2012 and 2013, was thereafter finalized. Finally, control of illegal mining began on August 12th 2014, as a result of an earthquake in the area, and has caused a significant reduction of this pollutant in the vicinity of San Antonio de Pichincha and surrounding areas.

Table 3 records the regulatory limits and the maximum values reached by carbon monoxide (CO) in the air environment of the MDQ. In *Figure 9* we can appreciate the trends of carbon monoxide during the ten years of monitoring, showing a constant decrease over this time, behavior that can be observed in almost all the monitoring stations. The significant decrease during the years 2004 to 2007 is potentially due to the years in which vehicular reviews decreased the percentage of evasion and also thanks to the arrival of vehicles with better technologies. Since 2008, concentrations remain constant.

Table 4 records the regulatory limits and maximum values for nitrogen dioxide (NO_2) in the air environment of the MDQ.

Figure 10 shows the trends of NO_2 in all monitoring stations for the period 2004 to 2014. With regard to the average timescale, from 2006 there is no exceedance of the standard in any of the stations.

Spatial distribution maps for the case of nitrogen dioxide show a gradual decrease in areas with concentrations above 40 $\mu g/m^3$ (annual standard) beginning in 2012. This decrease is potentially explained by the year's weather and also by the improvement of the quality of fuels nationwide from January 2012 (*Map 6*).

The highest concentration of this contaminant is located in the south central sector around the Puengasí reservoir: Monjas, the General Rumiñahui highway and Simón Bolívar Avenue, followed by the sectors of Cumbaya and Nayón. The high emissions in these sectors of the MDQ are potentially explained by the high traffic volumes in the area and the speed of traffic flow.

Table 5 records the regulatory limits and maximum values reached by tropospheric ozone (O_3) in the air environment of the MDQ.

In *Figure 11* the trend of the average eight-hour ozone concentration from 2004 to 2014 can be seen and shows cyclical behavior in accordance with weather conditions (solar radiation). Sectors with higher ozone concentrations correspond to peripheral areas of the MDQ, as well as sectors with the greatest altitude above sea level. This is explained by the fact that ozone is a secondary pollutant formed from emissions of nitrogen dioxide and unburned hydrocarbons carried by the wind and by the effects of solar radiation.

Table 6 records the regulatory limits and maximum values for sulfur dioxide (SO_2) in the air environment of the MDQ.

From *Figure 12* we can appreciate that this pollutant has not exceeded the annual standard since 2004. Rural concentrations, monitored from 2008, peaked in 2010 and have subsequently been declining to be equal to the corresponding regional values. It should be noted that from 2012 rural areas were no longer influenced by the diesel sold nationally (7,000 ppm sulfur), which was replaced by Premium diesel (<500 ppm), a potential explanation for the decreased concentrations of sulfur in this area. This same chart shows that since 2012 average concentrations of SO_2 at street level are lower than the concentrations in the Los Chillos and El Camal stations.

Map 7 displays the spatial distribution of sulfur dioxide, showing a significant decrease in emissions in the year 2011 compared with previous years, this is due to nationwide improvements in fuel. The area of

Mariscal Sucre Avenue

Photo: Marin Jaramillo

CO Carbon Monoxide

	Value	Period	Value	Period
Ecuadorian Standard	10 mg/m³	8 hours	30 mg/m³	1 hour
WHO guideline	10 mg/m³	8 hours	30 mg/m³	1 hour
Maximum value (2005 -2014)	6.92 mg/m³ año 2004 Carapungo	8 hours		

Table 3. Carbon Monoxide
Elaborated by IAMQ, 2016

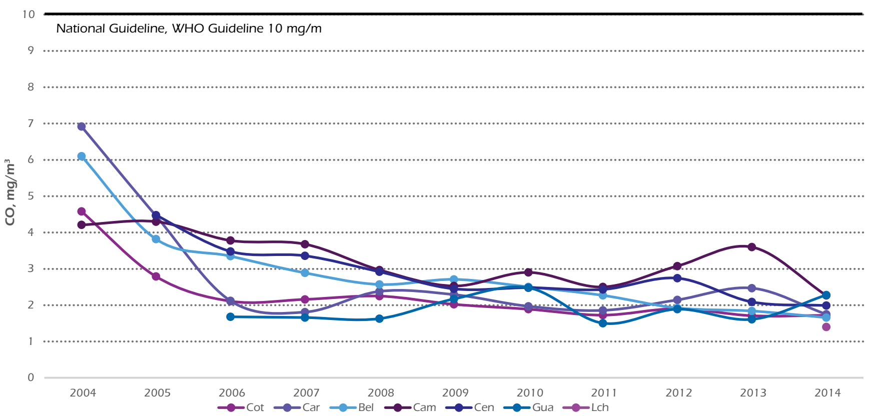


Figure 9. CO Tendencies (mg/m³) 2004-2014, maximum 8-hour average.

Health effects: Hypoxia (lack of oxygen) produced by CO inhalation can affect the heart, brain, platelets, and vascular endothelium. CO is associated with decreased visual perception, working capacity, manual dexterity, and the ability to learn.
Pollution sources: Product of the incomplete combustion of fossil-fuels. Gas vehicles are the biggest source.

Elaborated by IAMQ, 2016

NO2 Nitrogen Dioxide

	Value	Period	Value	Period
Ecuadorian Standard	40 µg/m³	1 year	200 µg/m³	1 hour
WHO guideline			200 µg/m³	1 hour
Maximum value (2005-2014)			259.9 µg/m³ año 2004 Carapungo	1 hour
Critical stations	Cumbayá, Necochea Street, Playón de la Marín, Basílica and Belisario			

Table 4. Nitrogen Dioxide
Elaborated by IAMQ, 2016

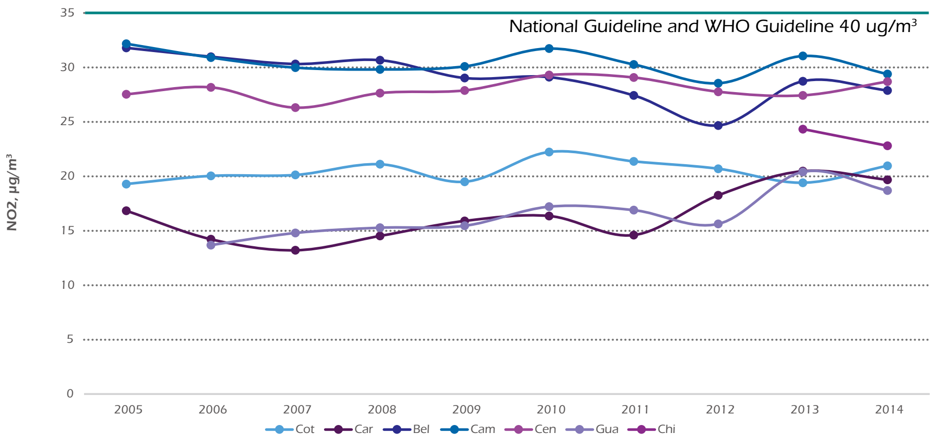


Figure 10. NO_2 Tendencies (ug/m³) 2004-2014, maximum 8-hour average.

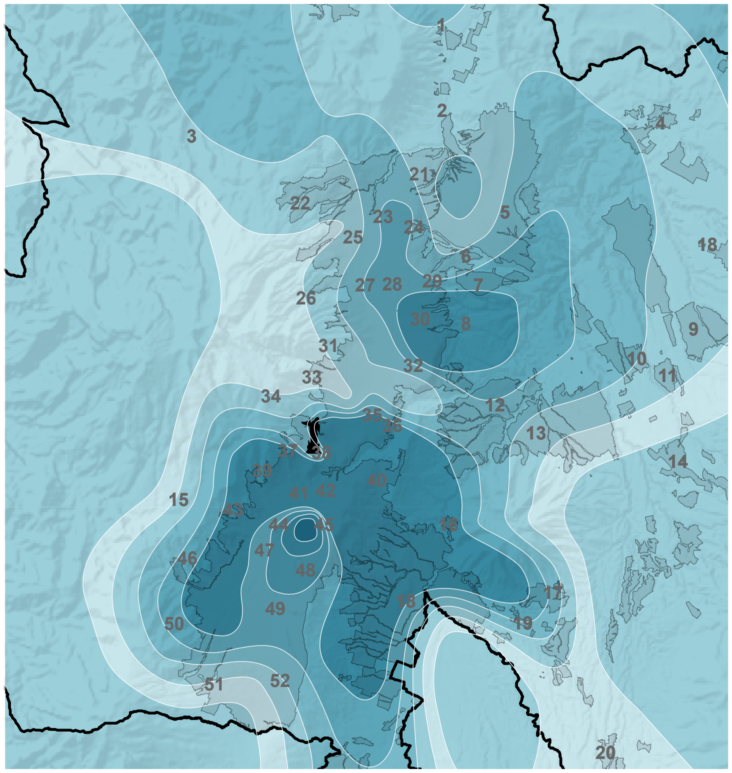
Health effects: NO_2 causes pulmonary irritation, bronchitis, pneumonia, significant reduction of respiratory resistance to infections. Continued exposure to high concentrations increases the incidence of respiratory diseases in children and worsens the conditions of asthmatics and people with and chronic respiratory diseases.
Pollution sources: NO_2 is formed due to the oxidation of the atmospheric nitrogen used in the combustion process (vehicles, industrial plants, thermal power stations and incineration plants).

Elaborated by IAMQ, 2016

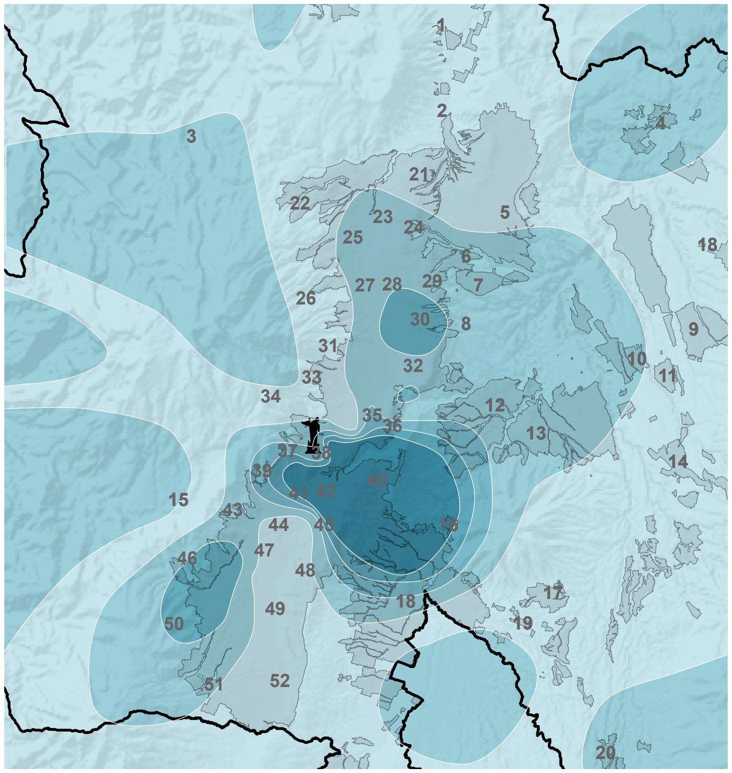
6 Map Contamination trends of NO_2

NO2

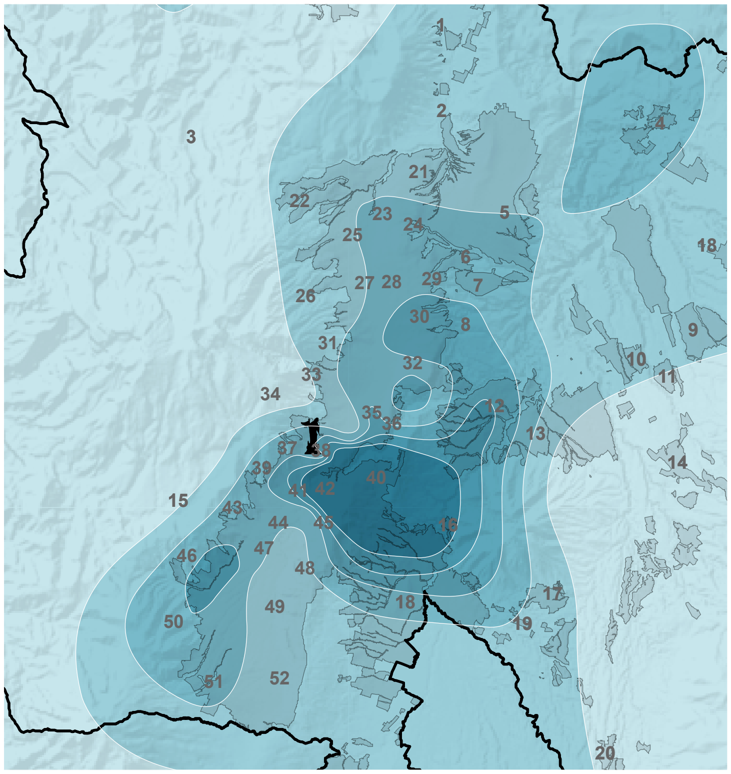
Year 2011



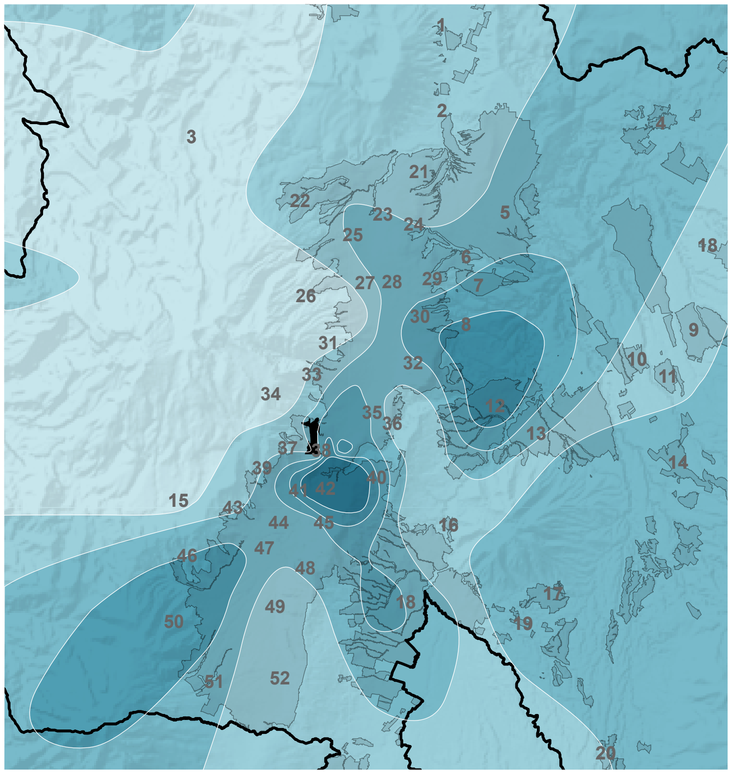
Year 2012

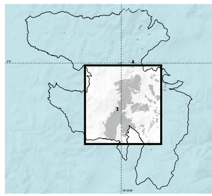


Year 2013



Year 2014





NO_2 µg/m³

- Less than 10
- 10 - 20
- 21 - 30
- 31 - 40
- 41 - 50
- 51 - 60

1 San Antonio
2 Pomasqui
3 Nono
4 Guayllabamba
5 Calderón
6 Llano Chico
7 Zámbiza
8 Nayón
9 Yaruquí
10 Puembo
11 Tababela
12 Cumbayá
13 Tumbaco
14 Pifo
15 Lloa
16 Guangopolo
17 La Merced
18 Conocoto
19 Alangasí
20 Píntag
21 Carcelén
22 Condado
23 Ponceano
24 Comité del Pueblo
25 Cotocollao
26 Cochapamba
27 Concepción
28 Kennedy
29 San Isidro del Inca
30 Jipijapa
31 Rumipamba
32 Iñaquito
33 Belisario Quevedo
34 San Juan
35 Mariscal Sucre
36 Itchimbía
37 La Libertad
38 Centro Histórico
39 Chilibulo
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41 La Magdalena
42 Chimbacalle
43 La Mena
44 San Bartolo
45 La Ferroviaria
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47 Solanda
48 La Argelia
49 Quitumbe
50 La Ecuatoriana
51 Guamaní
52 Turubamba

the Quitumbe bus terminal has ceased to be an important point of emission. Sectors with higher emissions, such as San Rafael, Cumbayá and Guangopolo have been identified as well as the arrival of this pollutant from Cayambe and Imbabura. This entry of pollutants is potentially explained by the presence of major industries such as cement and food producers in this area of influence; such industries use diesel and bunker fuel.

Table 7 records the regulatory limits and maximum values reached by coarse particulate matter (PM_{10}) in the air environment of the MDQ.

The analysis of the annual average of PM_{10}, shown in *Figure 13*, shows increases in all monitoring stations compared with the figures for 2014. The exception is the annual average in Carapungo, showing a decrease of 8%.

The information generated reveals that for the year 2014 PM_{10} pollution came from the south, mainly the southeast. Contaminants principally arrived from the Carretas area in the sector of the North Pan American highway.

During 2015, PM_{10} arrived mainly from the southwest and northeast. This means an influence coming from the areas of the Bicentennial neighborhood, San Juan de Calderón and Calderón, and to a lesser extent from the entrance zone to Carapungo in the area of the intersection of the North Pan American highway and Simón Bolívar Avenue.

In the sector of Tumbaco for the year 2014 PM_{10} came from three areas: the northeast, corresponding to the area of the Mariscal Sucre Airport, from Pifo in the east, potentially from stone quarrying areas or from the construction of roads in the sector, and from the southwest due to the construction of the Ruta Viva highway. During 2015, PM_{10} pollution in Tumbaco derived mainly from the east and southeast, from stone quarrying sites in the area. *Table 8* shows the concentration of $PM_{2.5}$ in the MDQ.

In addition, from research conducted by the Laboratory of Research Analysis and Monitoring, it is known that particulate matter PM_{10} for the Metropolitan District of Quito is mostly formed by emissions from burning fossil fuels (68%), followed by the geological material released from re-suspension on unpaved roads or construction sites and material coming from soil erosion (20%). Of this material, 6% comes from the re-suspension of road matter such as from breaking, tires, etc.

Figure 14 records the regulatory limits and maximum values reached by coarse particulate matter ($PM_{2.5}$) in the air environment of the MDQ.

The annual average trend analysis does not show a significant difference in the concentrations of this pollutant over the last three years. Concentrations have exceeded the national standard since 2005. The rate of exceedance has decreased from 366% in 2005 to 253% in 2014.

An analysis of the Carapungo station's area of influence has been performed. In 2013, $PM_{2.5}$ pollution arrived mainly from the northeast. The pollutants were carried from the area of the Bicentennial neighborhood, San Juan de Calderón and Calderón. By 2014, the winds carried contaminants from the northwest to the southwest, potentially from the areas of Carcelén and the North Pan American highway. In 2015 pollutants came from the west and southwest, potentially from the area of the North Pan American highway and its intersection with Simón Bolívar Avenue, where vehicular traffic increased over the previous year due to an increased circulation of public buses.

The analysis of the area of influence of the Belisario station shows that in 2013 $PM_{2.5}$ pollution came from around the station, América Avenue and its intersection with Atahualpa Avenue and Republic Avenue, but mainly from Antonio José de Sucre Avenue (Occidental Avenue), from the sector of El Bosque to Mariana de Jesús Avenue. During 2014 behavior was similar to 2013; however, the greatest contribution to pollution in the sector arrived from Naciones Unidas Avenue, Gaspar de Villaroel Avenue and their intersections

Measurement of emissions opacity in randomized checks of private bus companies in the La Marin sector

Photo: Metropolitan News Agency

O_3

Ozone

	Value	Period
Ecuadorian Standard	100 µg/m³	8 hours
WHO guideline	100 µg/m³	8 hours
Maximum value (2005-2014)	153.4 µg/m³ year 2004 Tumbaco	
Critical stations	Cruz Loma, Pomasqui, San Antonio de Pichincha, Tumbaco	

Table 5. Ozone
Elaborated by IAMQ, 2016

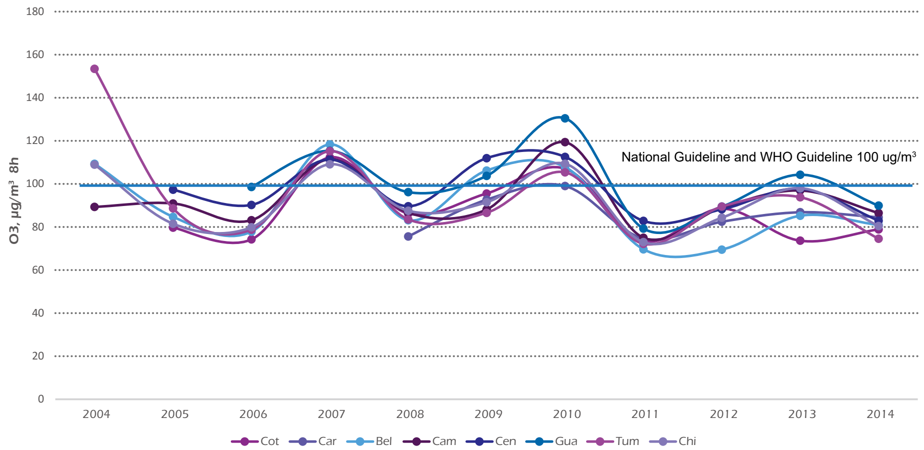


Figure 11. O_3 Tendencies (ug/m³) 2004-2014, maximum 8-hour average.

Health effects: High concentrations of O_3 produce ocular, nose and throat irritation, coughs, difficulty and pain during deep breathing, substernal pain, chest pressure, general pain, weakness, nausea, and headaches.
Pollution sources: O_3 is not directly expelled into the atmosphere; it is produced by photochemical reactions between nitrogen oxides and volatile organic compounds, under the influence of solar radiation.

Elaborated by IAMQ, 2016

SO_2

Sulfur dioxide

	Value	Period	Value	Period	Value	Period
Ecuadorian Standard	60 µg/m³	1 year	125 µg/m³	24 hours	500 µg/m³	10 min
WHO guideline	50 µg/m³	1 year	20 µg/m³	24 hours	500 µg/m³	10 min
Maximum value (2005-2014)	21.7 µg/m³ El Camal	1 year	111.6 µg/m³ year 2005 El Camal.	24 horas		
Critical stations	Los Chillos and Camal					

Table 6. Sulfur Dioxide
Elaborated by IAMQ, 2016

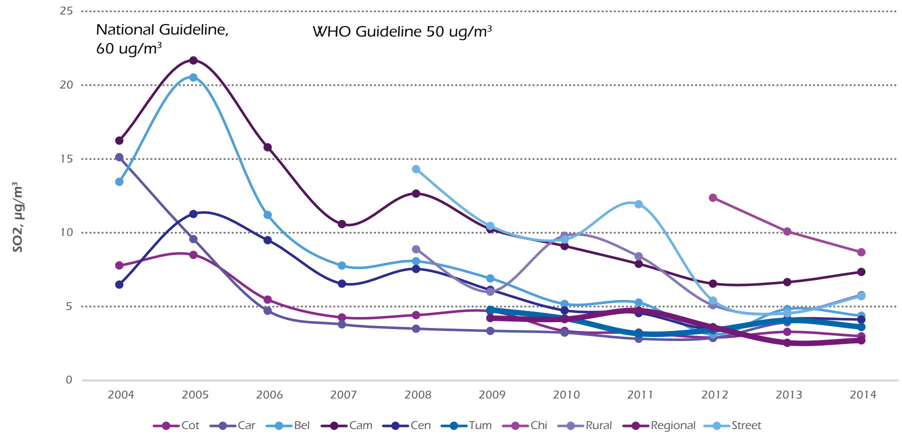


Figure 12. Tendencies SO_2 (ug/m³) 2004-2014, maximum 8-hour average

Health effects: High concentrations create breathing difficulty, conjunctivitis, and severe irritation of airways and lungs. A cause of bronchoconstriction, bronchitis, tracheitis, and bronchospasms, worsening of existing respiratory and cardiovascular diseases and death.
Pollution sources: Combustion of fossil-fuels with sulfur content (vehicles and industries).

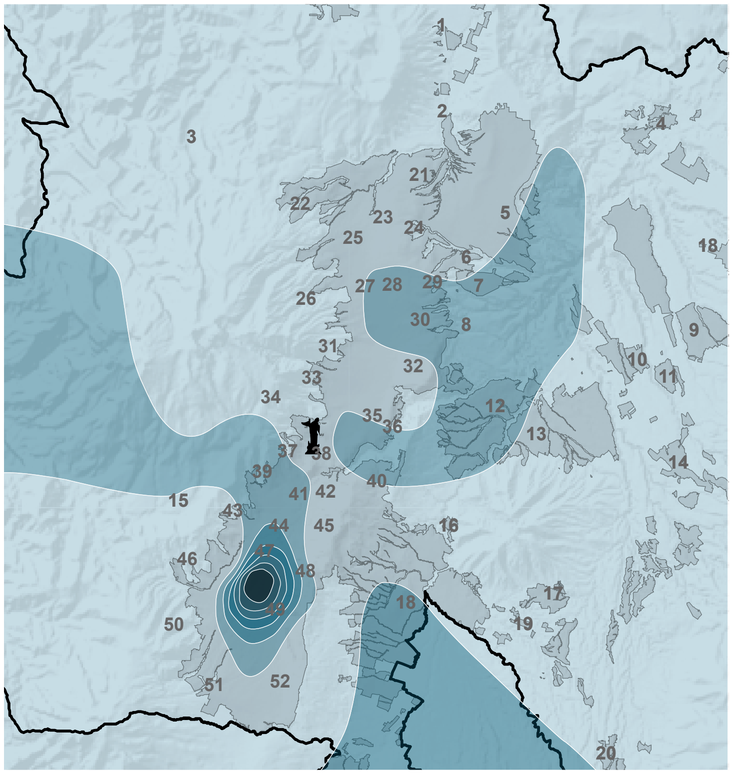
Elaborated by IAMQ, 2016

SO2

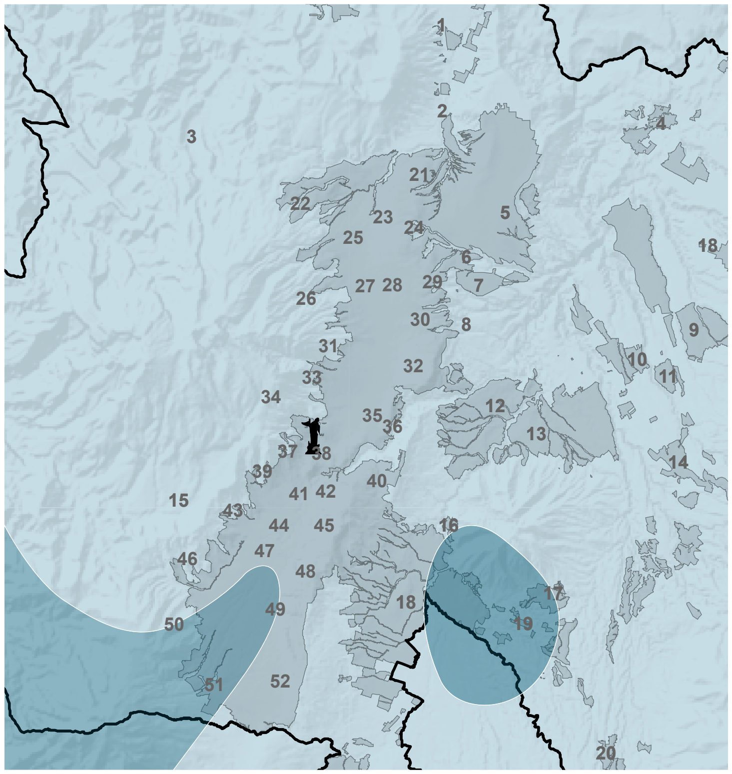
7 Map

SO_2 contamination trends

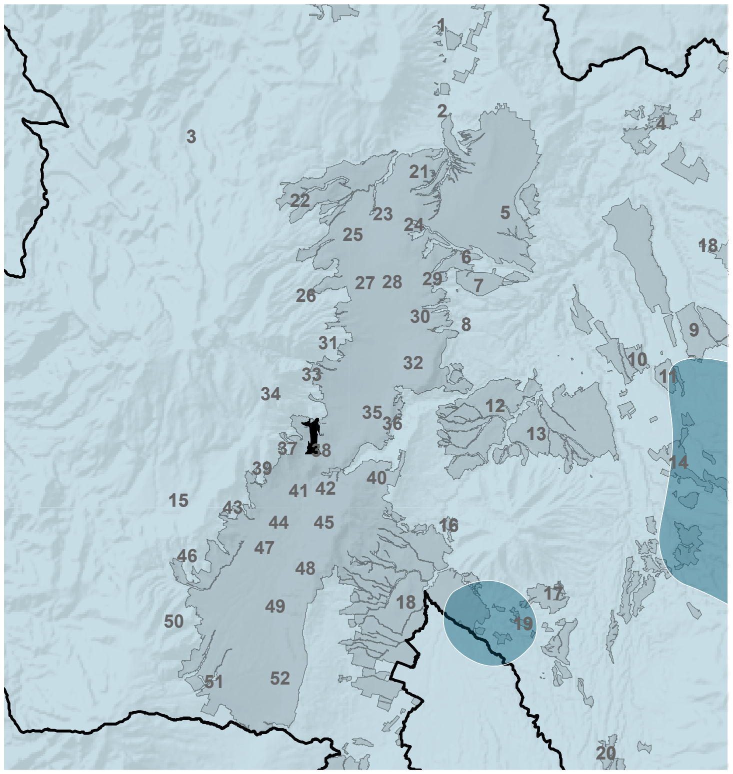
Year 2011



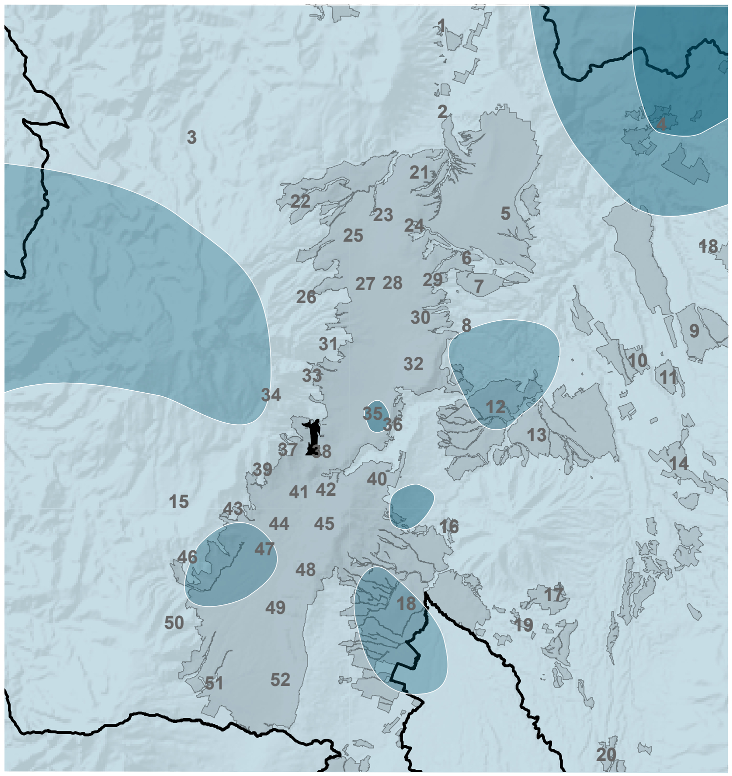
Year 2012

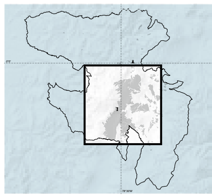


Year 2013



Year 2014





SO_2 µg/m^3
- Less than 10
- 10 - 20
- 21 - 30
- 31 - 40
- 41 - 50
- 51 - 60
- 61 - 70
- 71 - 80

1 San Antonio
2 Pomasqui
3 Nono
4 Guayllabamba
5 Calderón
6 Llano Chico
7 Zámbiza
8 Nayón
9 Yaruquí
10 Puembo
11 Tababela
12 Cumbayá
13 Tumbaco
14 Pifo
15 Lloa
16 Guangopolo
17 La Merced
18 Conocoto
19 Alangasí
20 Píntag
21 Carcelén
22 Condado
23 Ponceano
24 Comité del Pueblo
25 Cotocollao
26 Cochapamba
27 Concepción
28 Kennedy
29 San Isidro del Inca
30 Jipijapa
31 Rumipamba
32 Iñaquito
33 Belisario Quevedo
34 San Juan
35 Mariscal Sucre
36 Itchimbía
37 La Libertad
38 Centro Histórico
39 Chilibulo
40 Puengasí
41 La Magdalena
42 Chimbacalle
43 La Mena
44 San Bartolo
45 La Ferroviaria
46 Chillogallo
47 Solanda
48 La Argelia
49 Quitumbe
50 La Ecuatoriana
51 Guamaní
52 Turubamba

PM10

Particulate Matter 10

	Value	Period	Value	Period
Ecuadorian Standard	50 µg/m³	1 year	100 µg/m³	24 hours
WHO guideline	20 µg/m³	1 year	50 µg/m³	24 hours
Maximum value (2005-2014)	88.5 µg/m³ year 2005 Guamaní	1 year	191 µg/m³ year 2005 Guamaní	24 hours
Critical stations	San Antonio de Pichincha			

Table 7. Particulate Matter 10
Elaborated by IAMQ, 2016

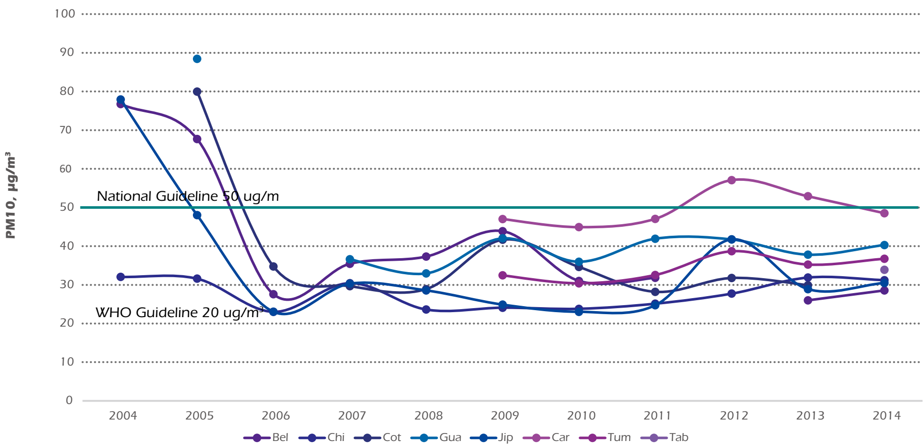


Figure 13. PM_{10} Tendencies (ug/m³) 2004-2014, maximum 8-hour average.

Health effects: PM_{10} causes irritation to the respiratory tracts, worsens asthma and fosters cardiovascular diseases. It is related to silicosis and asbestosis. It causes the deterioration of the breathing function (short-term). It is connected with the evolution of chronic diseases, cancer, and premature death (long-term).
Pollution sources: Wind erosion, unpaved traffic roads and construction activities. Combustion processes (industry and automotive vehicles).

Elaborated by IAMQ, 2016

PM2.5

Particulate Matter 2.5

	Value	Period	Value	Period
Ecuadorian Standard	15 µg/m³	1 year	50 µg/m³	24 hours
WHO guideline	10 µg/m³	1 year	25 µg/m³	24 hours
Maximum value (2005-2014)	53.97 µg/m³ year 2005 Guamaní	1 year	53.97 µg/m³ year 2005 Guamaní	24 hours
Critical stations	Cotocollao, Carapungo, Belisario, Camal, Centro, Los Chillos			

Table 8. Particulate Matter 2.5
Elaborated by IAMQ, 2016

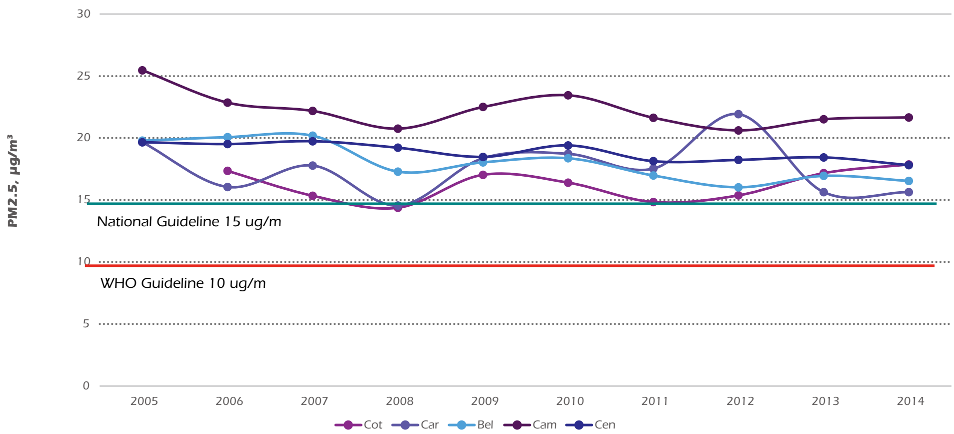


Figure 14. $PM_{2.5}$ Tendencies (ug/m³) 2004-2014, maximum 8-hour average.

Health effects: PM2.5 has the capacity to enter the alveolar space or the blood stream increasing the risk of chronic cardiovascular diseases and premature death.
Pollution sources: Combustion processes (industry, thermoelectric generation). Forest fires and vegetation burning. Purification and metals processing.

Elaborated by IAMQ, 2016

with Los Shyris Avenue and Amazonas Avenue. 2015 again shows a behavior similar to 2013, the main contribution of emissions coming from Antonio José de Sucre Avenue.

Random checks on public roads

Random checks on public roads are performed by the Metropolitan Transit Agency in coordination with the Secretary of the Environment, and inspect private and public transport vehicles on issues relating to standards[8].

The following parameters apply in randomized controls for different types of vehicle:

1. Private vehicles and taxis: controls to verify that documentation is approved and current in relation to compliance with the Vehicle Technical Review.
2. Public transport vehicles: measurement of emissions opacity, review tire tread, suitable windshield condition, suitable tailpipe condition, controls to verify that documentation is approved and current in relation to compliance with the Vehicle Technical Review.
3. School transport vehicles: measurement of emissions opacity, suitable windshield condition, suitable tailpipe condition, seat belts, signage for student safety, controls to verify that documentation is approved and current in relation to compliance with the Vehicle Technical Review.

In the case of non-compliance of vehicles inspected in random checks on public roads, a citation according to the provisions of Ordinances 213 and 159 shall apply.

During a randomized control the Secretary of the Environment puts special emphasis on the parameter of opacity, due to its negative visual impact, an element of road transport which has remained a concern of citizens, especially in relation to diesel powered public transport. Opacity limits relating to Ordinance 213 can be seen in *Table 9*.

Table 9. Opacity limits.

Year model	% opacity
2000 and after	50
1999 and before	60

Source: Norma INEN 2207:2002, opacity

Random controls mean that drivers become aware of these regulation violations and establish preventive and corrective actions in their transport units, which in the medium and long term means a reduction in the rates of opacity and mechanical failures, thus safeguarding the health of citizens.

Evaluation of random checks on public roads and statistical monthly reports has identified the following results:

For the year 2015, 13,072 vehicles were inspected. Of these, 68% (8,870 units) were private and 32% were public use vehicles (3506 buses, 174 taxis, and 522 school buses).

Of the 13,072 vehicles inspected between January and December 2015, approximately 53% (6,840) have been cited, of these 17% (1,153) are buses, 1% (67) taxis, 1% (51) school buses and 81% (5,569) private cars.

Of the cited buses (1,153 units), 40% (458 units) were cited for failing to report to their last vehicular technical review, which is mandatory every six months, 32% (374 units) for failures in the exhaust system, that is for breach of the rules concerning the location of this component, the absence thereof, or for having two tailpipes,

8 Ordinance 213 sanctioned on the 18th of April 2007 and Ordinance 159 of the 20th of December 2011.

27% (312 units) for high levels of opacity and 1% (9 units) for problems with the windshield.

As for the school buses cited in the period September to December 2015, a total of 51 units were cited of which 94% (48 units) because they had not submitted to the mandatory vehicular technical review, and 6% (3 units) for exceeding regulatory limits of opacity and for tailpipe design modifications.

In the period between January 20th and March 31st 2016, 2,690 vehicles were inspected, of which 51.22% (1,378 units) were public transport buses, 32.63% were private vehicles (878), 16.05% were school vehicles (432 units), with two taxi units representing 0.07% of the total inspected vehicles.

Of the 2,690 vehicles inspected 1,057 units were cited, of which 53% (557) were buses, 43% (457) were private vehicles, and 4% (43 units) were used for school transport.

The majority of buses (63%, 352 units) were cited for exceeding the permitted limits of opacity, 22% (122 units) for failures in the exhaust system, that is for breach of the rules concerning the location of this component, surface defects, or for having two tailpipes, 15% (81 units) were cited for not having documents supporting the approval of compulsory vehicle technical inspection and the remaining 0.3% of units (2 buses) for defects in the windshield that did not allow proper visibility and were a security risk for the occupants of the bus.

Environmental noise

Currently the Environmental Noise Monitoring Network of the Secretary of the Environment has three fixed points located in the City Center, Jipijapa and Carapungo stations (Camal station during 2012 and 2014), in the same locations as the air monitoring stations.

This network has fixed stations for monitoring environmental noise and these monitor continuously - 24 hours a day, every day of the year. Data are reported as equivalent sound level (Leq) in decibels, which corresponds to the measurement of the noise level averaged over the measurement time. This measure is used when the noise varies with time.

There is no national or district policy regarding ambient noise, and for this reason the data generated by the network are compared with the World Health Organization's guidelines. These guidelines represent optimal values to ensure the health of the people subjected to noise in the monitored sectors, but do not take into account the conditions, characteristics and limitations of the site monitored.

The average day and night records of the three monitoring stations for the years 2012 and 2014 are all under 65 dB, while for the city center station they are below 60 dB. The average according to the WHO guideline should be 55 dB.

The average daytime noise level is eight times higher than the WHO guidelines (55 dB) in the Camal and Jipijapa sectors (64 dB), while in the Historic Center of the city (58 dB) noise is two times higher. During the night the noise levels become 30 times more than that established by the WHO guidelines: 45 dB in Jipijapa and 60 dB in Camal, while in the Historic Center noise becomes five times greater than that stipulated by the guidelines. It should be noted that current regulations for similar cities in the region have rules setting the decibel level for daytime environmental noise between 65 and 75 dB, while for nighttime hours the range is between 55 and 70 dB, depending on the sectors analyzed.

Applying this standard, the noise levels measured by stations in the Metropolitan District would comply with the rules.

Historic Center of Quito

EFFECTS CAUSED BY CLIMATE CHANGE

The state of the climate

Today, climate change is one of the biggest environmental challenges and concerns the whole of humanity. There is broad scientific consensus that the Earth is experiencing global warming resulting from an increase in gases from anthropogenic origin released into the Earth's atmosphere. As a result, the planet's climate has begun to change.

Changes in precipitation

Since future predictions of precipitation are inconclusive regarding large increases or decreases, the biggest threat would be successive years of drought. Therefore, precipitation levels from three historically dry years (1992, 1995, 2001) will be repeated in cycles of three-year droughts during the period from 2007 to 2050 (Secretary of the Environment – Municipal MDQ, 2014).

The MDQ has a wide altitudinal variation (500-4800 masl), which corresponds to a warm equatorial zone with 75% relative humidity and an average temperature of 14.78°C (UNEP et al, 2011).

It is estimated that between 1891 and 1999 the average temperature in the urban part of the MDQ increased between 1.2°C and 1.4°C, while precipitation had a general tendency to decrease, it has been determined that this trend represents a decrease of 8% in annual precipitation (Municipal MDQ, 2009) (*Figures 15 and 16*).

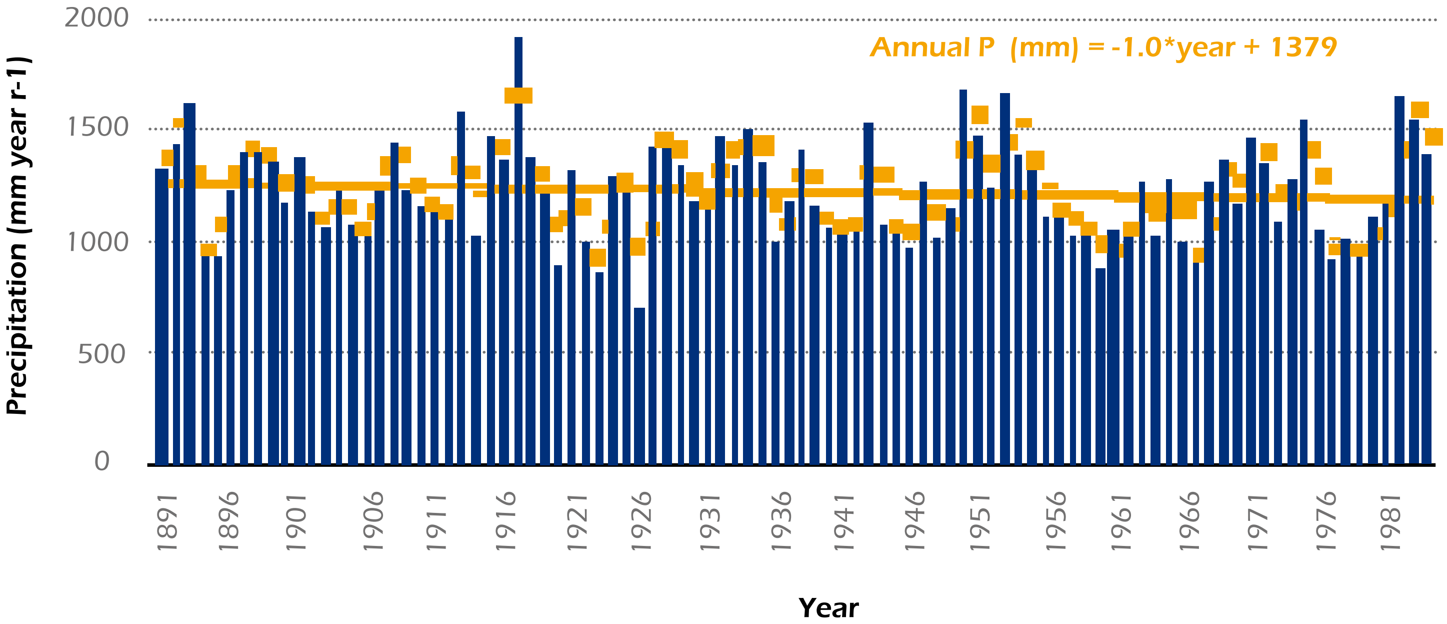


Figure 15. Annual precipitation levels
Source: Secretary of the Environment, 2009.

Tanlahua sector, San Antonio de Pichincha

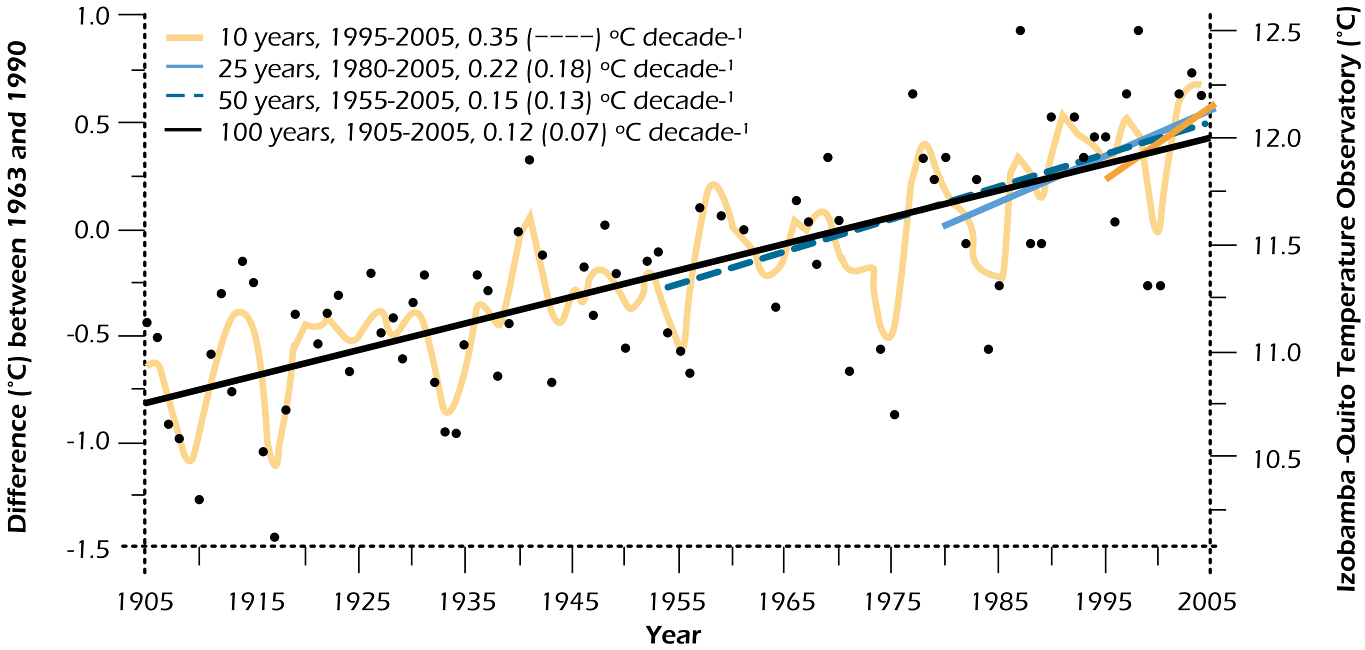


Figure 16. Temporal distribution of: (a) temperature; and (b) precipitation, based on data from the Quito Observatory station during the period 1981-1999 and analyzed by Inamhi.
Source: Barragán-Zambrano et al.,2011

Changes in temperature

Several studies have determined that the temperature increase by 2050 will be 2.5°C (*Map 8*). Also, there has been a considerable increase in floods, landslides and forest fires in the district.

Extreme events

On the subject of extreme events, the MDQ is exposed to multiple natural and anthropogenic threats that could directly affect the population and infrastructure located in vulnerable sectors. Landslides, floods and forest fires are the most frequent events in the territory, caused mainly by hydro-climatic and morphodynamic phenomena (Secretary of Security, 2015) (*Figures 17, 18 and 19*).

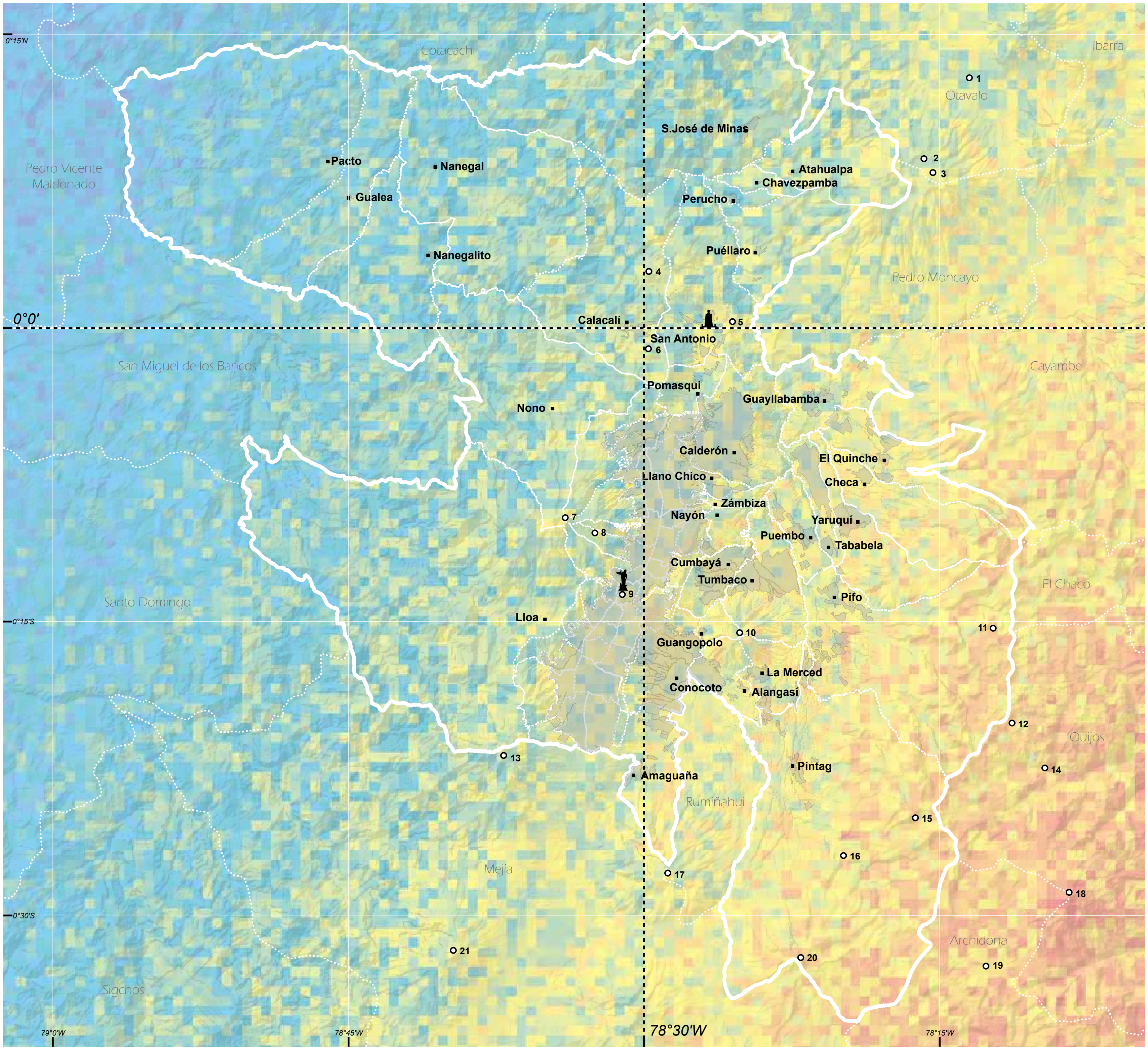
In accordance with these MDQ records, the study on Climate Trends Indices 'CLIMDEX' (Muñoz, 2013) considered ten stations in the Ecuadorian provinces of Pichincha and Napo, with daily time series records for the period 1984-2012 (28 years).

This study shows that the minimum and maximum temperatures are increasing at a rate of between 0 and 0.5°C per decade, which is consistent with the trend showing a decrease in the number of days and nights considered to be cold, and with the trend showing an increase in the number of warm nights and days.

Also, the number of consecutive dry days is increasing slightly throughout the study area, indicating that the days with precipitation tend to be less frequent and rainfall is more extreme.

Map 8

Spatial projection of the average changes in temperature by 2050 in the MDQ



- 2.5 to 2.75 Cº
- 2.3 to 2.5 Cº
- 2.2 to 2.3 Cº
- Less than 2.1 Cº

1 San Pablo lagoon 2,667m
2 Mojanda lagoon 3,725m
3 Negra lagoon 3,740m
4 Pululahua volcano 2,954m
5 Catequilla hill 2,635m
6 Casitahua volcano 3,240m
7 Rucu Pichincha 4,620m
8 Cruz Loma 4,080m
9 Panecillo 3,012m
10 Ilaló mount 3,175m
11 Nunalviro lagoon 4,120m
12 Sucus lagoon 3,908m
13 Atacazo volcano 4,400m
14 Papallacta lagoon 3,376m
15 Muerte Pungo lagoon 3,965m
16 De Secas lagoon 3,400m
17 Pasochoa volcano 4,120m
18 Antisana volcano 5,621m
19 La Mica lagoon 3,920m
20 Sincholahua volcano 4,780m
21 Corazón volcano 4,720m

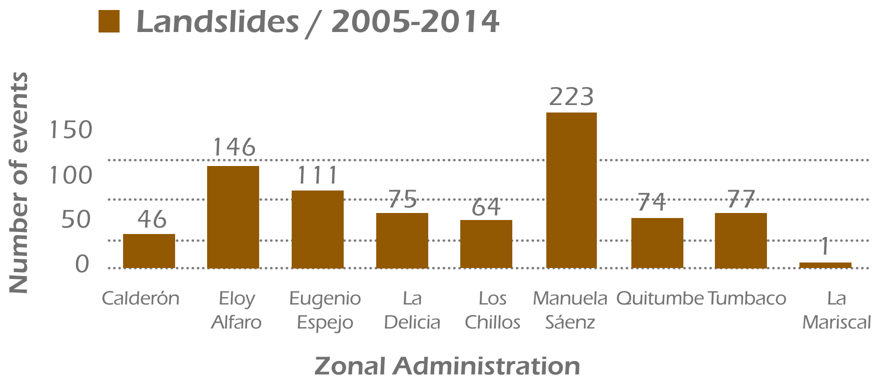


Figure 17. Landslides / 2005-2014

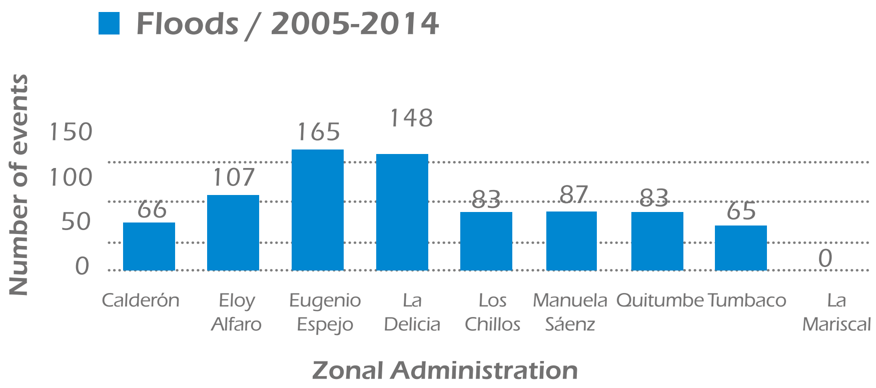


Figure 18. Floods 2005 - 2014

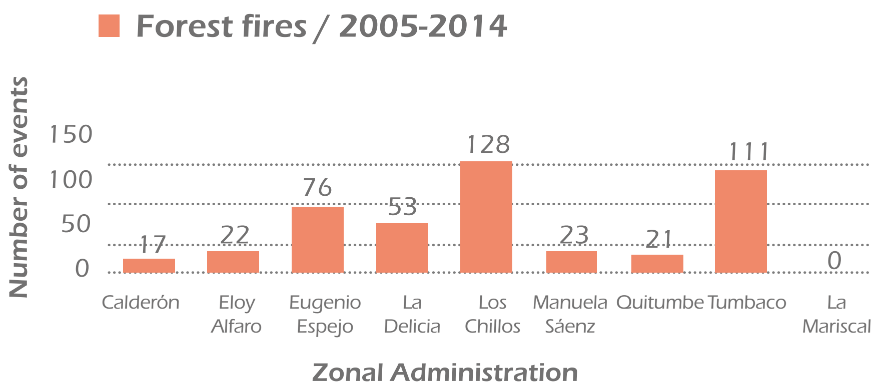


Figure 19. Forest fires 2005 - 2014

Source: Atlas of natural hazards and infrastructure exposition of the Metropolitan District of Quito.

Greenhouse gases in the MDQ

The inventory of the MDQ's Greenhouse Gas emissions (GHG) for 2011 was developed following the methodology of the Intergovernmental Panel on Climate Change (IPCC), which considers five categories of sources or carbon sinks as well as direct and indirect greenhouse gases (J . Baca, D. Enriquez, N. Narvaez, 2013):

- **Energy:** includes the total emissions of greenhouse gases resulting from combustion in stationary and mobile sources and fugitive emissions. In the fuel combustion categories the following sub-sectors are included: energy industries, manufacturing and construction, transportation and other sectors. Fugitive emissions include those related to oil and natural gas.
- **Industrial processes:** categorized as industrial activities not related to energy. The main sources of emissions are industrial production processes that chemically or physically transform materials such as cement production, lime production, the production and use of various mineral products, wood pulp, food and beverages etc.
- **Agriculture:** This category lists emissions from five sources: domestic livestock, rice cultivation, intentional burning of savannas, field burning of agricultural waste and agricultural soils.
- **Land use change in land use, and forestry (LULUCF):** this category includes changes in forests and other woody biomass, conversion of forests and grasslands, abandonment of managed lands and emissions and removals of CO_2 from the soil due to handling and changing land use.

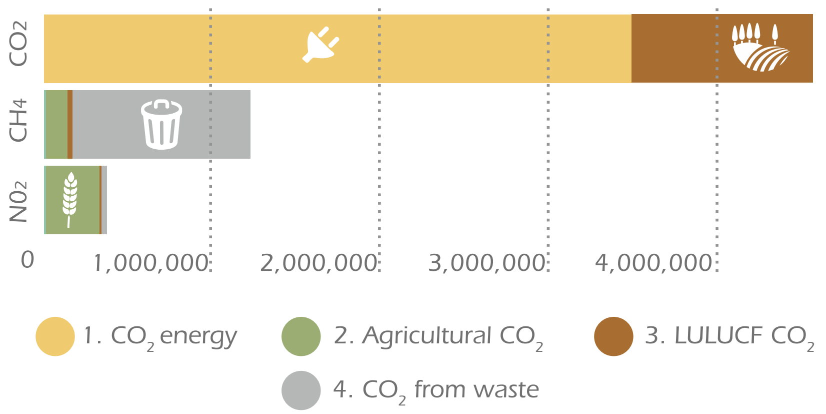
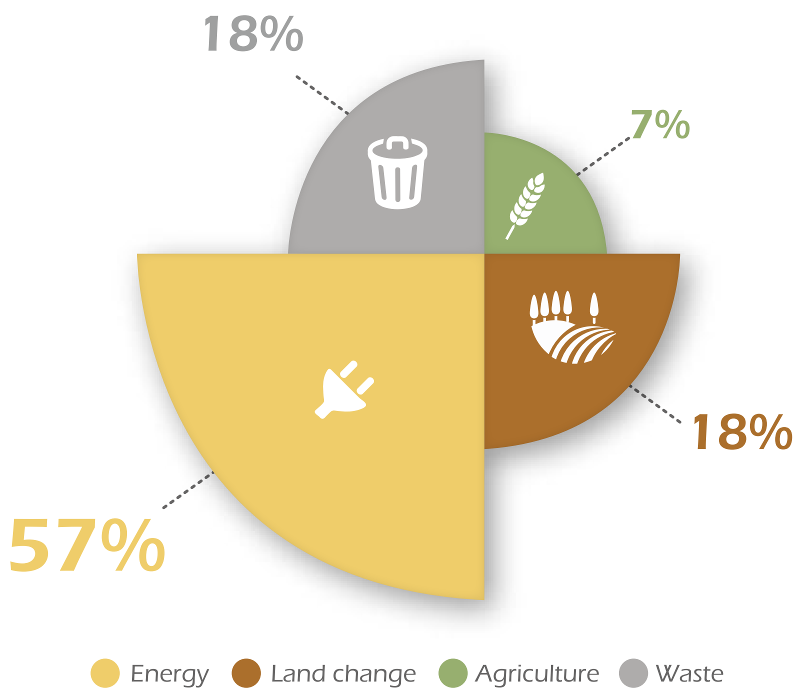


Figure 20. Direct GHG emissions, MDQ 2011 (tons CO_2-eq/year)
Source: Secretary of the Environment, Climate Change Team, Ecological Footprint of the MDQ, 2014.



Infographic 13. Distribution of direct GHG emissions by sectors, MDQ 2011 (%)
Source: Secretary of the Environment, Climate Change Team, Ecological Footprint of the MDQ, 2014.

- **Waste:** mainly the emissions from solid waste disposed in landfills and emissions associated with domestic and industrial wastewater.

In 2011 net emission of direct greenhouse gases in the Metropolitan District of Quito reached 6,180,065 Tons of CO_2-eq. These emissions were generated by the energy sector (57%), LULUCF (18%), waste (18%) and agriculture (7%) (*Figure 20* and *Infographic 13*).

MDQ GHG emissions and GHG emissions at national level

National inventories in the years 1990, 1994, 2000 and 2006, as well as inventories for the years 2003, 2007 and 2011 for the Metropolitan District of Quito have been developed using the IPCC methodology. For this reason, it is possible to make comparisons between MDQ emissions and the national reality.

Nationally, the agricultural sector is the largest contributor to total emissions, while in the case of the MDQ the highest emitter is the energy sector. This is explained by the characteristics of large urban centers, areas of high energy consumption and significant levels of fossil fuels burning and waste generation. Because of this phenomenon, emissions from the district's urban areas (such as energy and waste) are much more important than those mostly linked to rural areas (LULUCF or agriculture).

In addition to the energy sector, at the MDQ level the waste sector also shows a significant weight of GHG emissions, contrary to the scenario at national level. This phenomenon, like that of the energy sector, is related to the urban dynamics occurring in the MDQ, and the large population concentrations in its territory. The

geographical area of the MDQ represents less than 2% of the entire country, but its population is about 15% of the total. This implies a high rate of waste generation and, in parallel, significant levels of emissions from the waste sector.

Finally, it is noted that in the case of the MDQ the LULUCF sector generates higher GHG emissions than the agricultural sector; LULUCF is mainly associated with the loss of forests and grasslands due to urban growth and the expansion of the agricultural frontier. These results highlight the importance of policies to reduce the emissions of the MDQ focusing both around urban dynamics (mainly energy) and the appropriate management of rural territory (LULUCF and agriculture).

MDQ Carbon Footprint

Carbon Footprint (CF) is the amount of greenhouse gases emitted directly or indirectly by an individual, organization, event or product. The determination of Quito's CF was performed using the methodology of the Global Protocol for Community - GPC (ICLEI-WRI).

The carbon footprint of Quito is 5,164,946 tons of CO_2eq. These emissions are equal in magnitude to the CO_2 emissions generated by the use of electricity in more than 15 million urban households in Ecuador in a year, or carbon sequestered by 125 million trees in ten years, or GHG emissions avoided by recycling more than 1.8 million tons of combined solid waste.

The total CF of the MDQ is distributed as follows: the transport sector has the highest percentage of total emissions (56%), emitting 2,902,402 tons of CO_2e; the residential, commercial and institutional sectors generate emissions of 1,016,305 tons of CO_2e (20%); the solid waste industry emits 661,689 tons of CO_2e (13%); and the industrial sector emits 584,550 tons of CO_2e (11%).

The transport sector is the main contributor to the CF of the MDQ, with more than half of the total footprint, 2,902,402 tons of CO_2e during the year of analysis (56%).

According to the total composition of the carbon footprint by source emission, gasoline consumption in the transport sector is the most significant source of emissions, with 1,883,525 tons of CO_2e, representing 36% of the total CF. The second most important source of emissions is the consumption of diesel in the industry and transport sectors, 1,441,835 tons of CO_2e, representing 28% of the total CF. In third place of importance is the emission source of waste decomposition at the El Inga landfill site, which contributes 659,092 tons of CO_2e (13%) to the total CF. Next are: LPG (594,885 tons of CO_2e 12%), electricity (575,884 tons of CO_2e 11%), and incineration (2,596 tons of CO_2e, less than 0.1%). These figures are shown in *Figure 21*.

The 5.16 million tCO_2e of the MDQ (2011) represent 1.3% of the carbon footprint of Ecuador (2006). Excluding LULUCF and agriculture, which correspond mainly to rural areas, the carbon footprint of Quito is 13.7% of the CF of Ecuador. The MDQ population (2.4 million) represents 15% of the total Ecuadorian population (15.5 million).

Measurement of the carbon footprint of the Metropolitan District of Quito was made following the guidelines established by the international standard ISO 14064:1 for greenhouse gases, the Greenhouse Gas Protocol (GHG Protocol) measurement tools, and the MC_3 methodology (Compound Method of Accounting) by CarbonFeel.

- **Scope 1.** Direct GHG emissions: Emission sources that are owned or are controlled by the organization. It is mandatory to report emissions under this scope according to the ISO 14064 standard.
- **Scope 2.** Indirect GHG energy emissions: Indirect GHG emissions coming from electricity generation from external sources and consumed by the organization. It is also mandatory to report emissions under this scope according to the ISO 14064 standard.

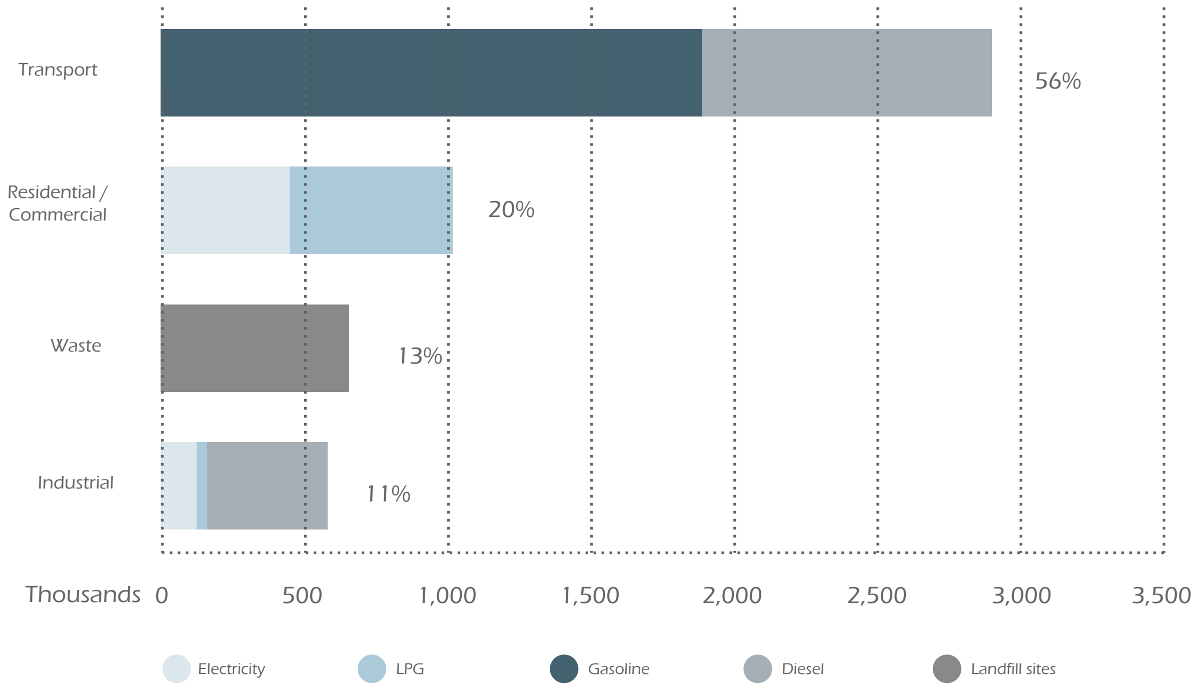


Figure 21. Total Carbon Footprint according to sector and emission source (tons of CO_2e)
Source: Secretary of the Environment, Cities Footprint Project, 2014.

- **Scope 3.** Other Indirect GHG Emissions: Indirect GHG emissions occur as a result of the activities of the organization, but from sources that are not controlled by it. Emissions under this scope are reported voluntarily according to the ISO 14064 standard (*Infographic 12*).

The total carbon footprint of the Municipal MDQ is 37,995 tons of CO_2e. The sources of GHG emissions that constitute the Municipal MDQ's CF, as established by ISO 14064, are divided into Scope 1, 2 and 3 emissions (*Infographic 14*). Scope 3 emissions are the highest component of the total footprint (35,418 tons of CO_2e, 93%), followed by Scope 1 emissions (1,448 tons of CO_2e, 4%) and Scope 2 emissions (1,128 tons of CO_2e, 3%).

The total carbon footprint of the Municipal MDQ is 37,995 tons of CO_2e. The sources of GHG emissions that constitute the Municipal MDQ's CF, as established by ISO 14064, are divided into Scope 1, 2 and 3 emissions (*Infographic 14*). Scope 3 emissions are the highest component of the total footprint (35,418 tons of CO_2e, 93%), followed by Scope 1 emissions (1,448 tons of CO_2e, 4%) and Scope 2 emissions (1,128 tons of CO_2e, 3%).

In accordance with the total composition of the carbon footprint by emission source it is observed that the construction of civil works (Scope 3) represents the most important source of emissions with 25,132 tons of CO_2e, representing 66% of the total CF. The second most significant source of emissions is the use and consumption of materials with 5,663 tons of CO_2e, representing 13% of the total CF.

Third in importance is the use of transport to move people to and from their homes, which uses 4,514 tons of CO_2e (Scope 3). This represents 12% of the total CF.

Carbon Footprint

The total CF of the Municipal government of the MDQ is distributed as follows: the collective of zonal administrations has the highest percentage of the total emissions (77%) emitting 29,154 tons of CO_2e. In second place is the administration of municipal companies with 5,013 tons of CO_2e (13%), and finally general administration with 3,827 tons of CO_2e (10%) (*Figure 22*).

Projected carbon footprint by 2032

To determine the 'Business as Usual [1]' (BAU) emission scenario by 2032 we must consider the expected evolution of the various socio-economic variables that characterize the city.

The main variables that determine the socio-economic scenario are the number of inhabitants in the city, the Gross Domestic Product per capita, the traffic fleet of the city, the number of industries registered per year and the amount of waste generated per year. Growth projections were considered for each of these factors.

2032 GHG emissions projected for a BAU scenario amount to 11,517,106 tons of CO_2e (*Figure 23*).

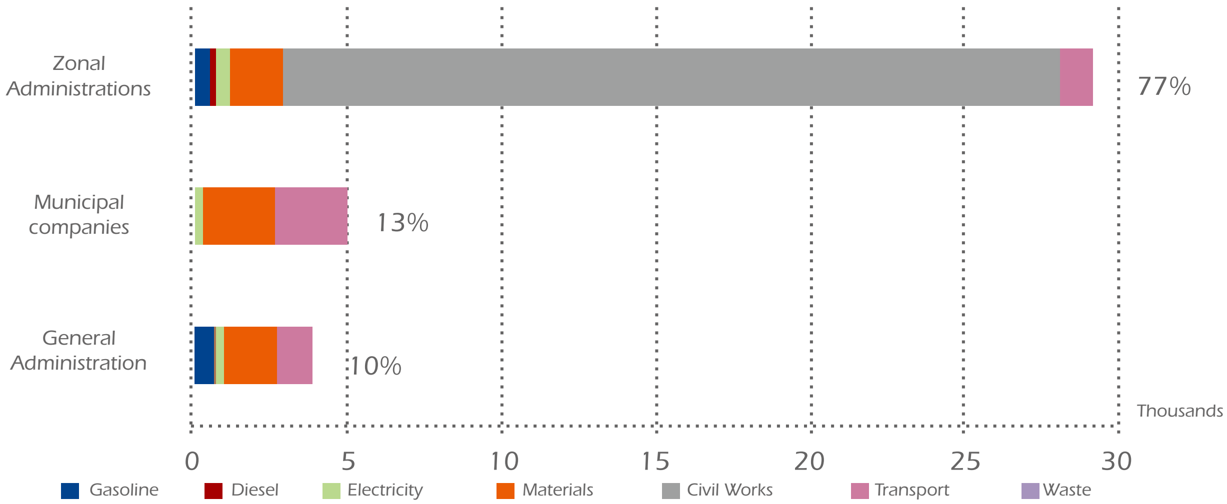
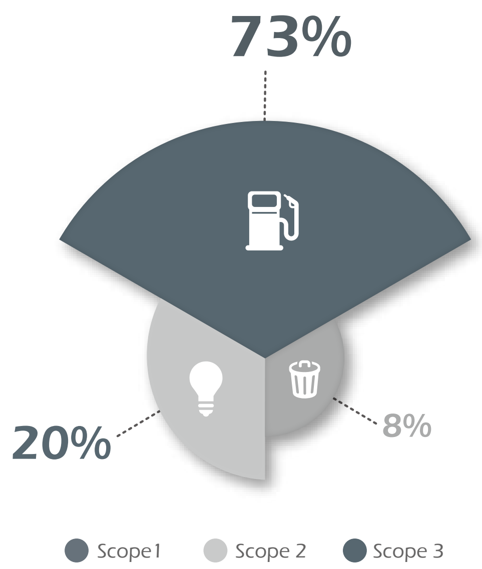


Figure 22. Total Carbon Footprint (CF) according to level and source of emission (tons CO_2e)
Source: Secretary of the Environment, Cities Footprint Project, 2014.



Infographic 14. Emission source according to scope
Source: Secretary of the Environment, Cities Footprint Project, 2014.

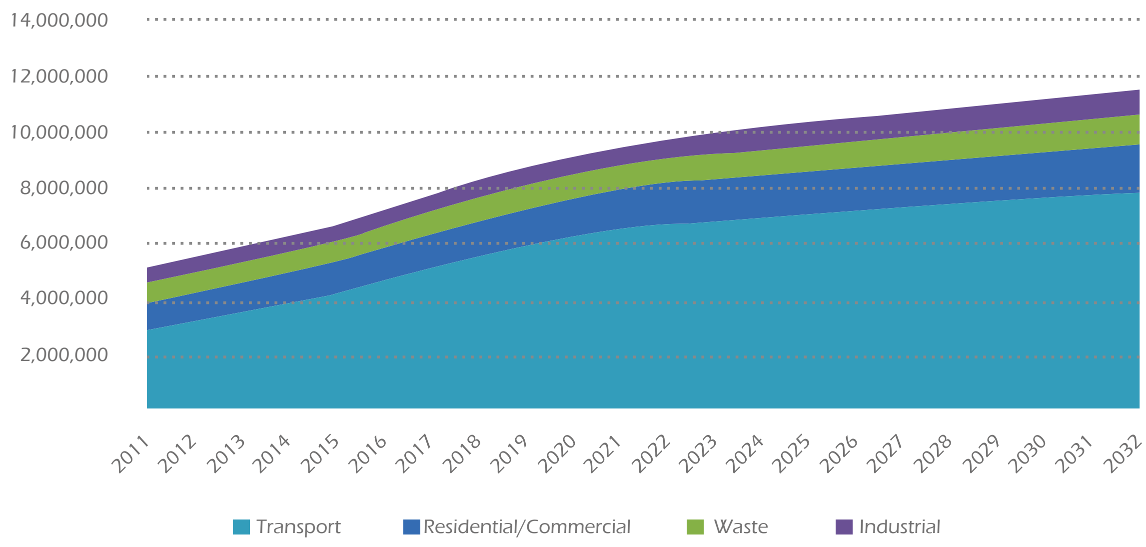


Figure 23. BAU scenario Carbon footprint to 2032, total and by sector in tons of CO_2e.
Source: Secretary of the Environment, Cities Footprint Project, 2014.

Vulnerability

Among the local impacts of climate change according to a recent study of vulnerability to climate change in the MDQ, are effects in the most vulnerable ecosystems as well as in the most vulnerable sectors and social groups (D. Enriquez, N. Narvaez, 2013).

Projections to the year 2050 show that vulnerability is focused on five sectors: water, health, agriculture, ecosystems and risks (forest fires) (*Infographic 15*).

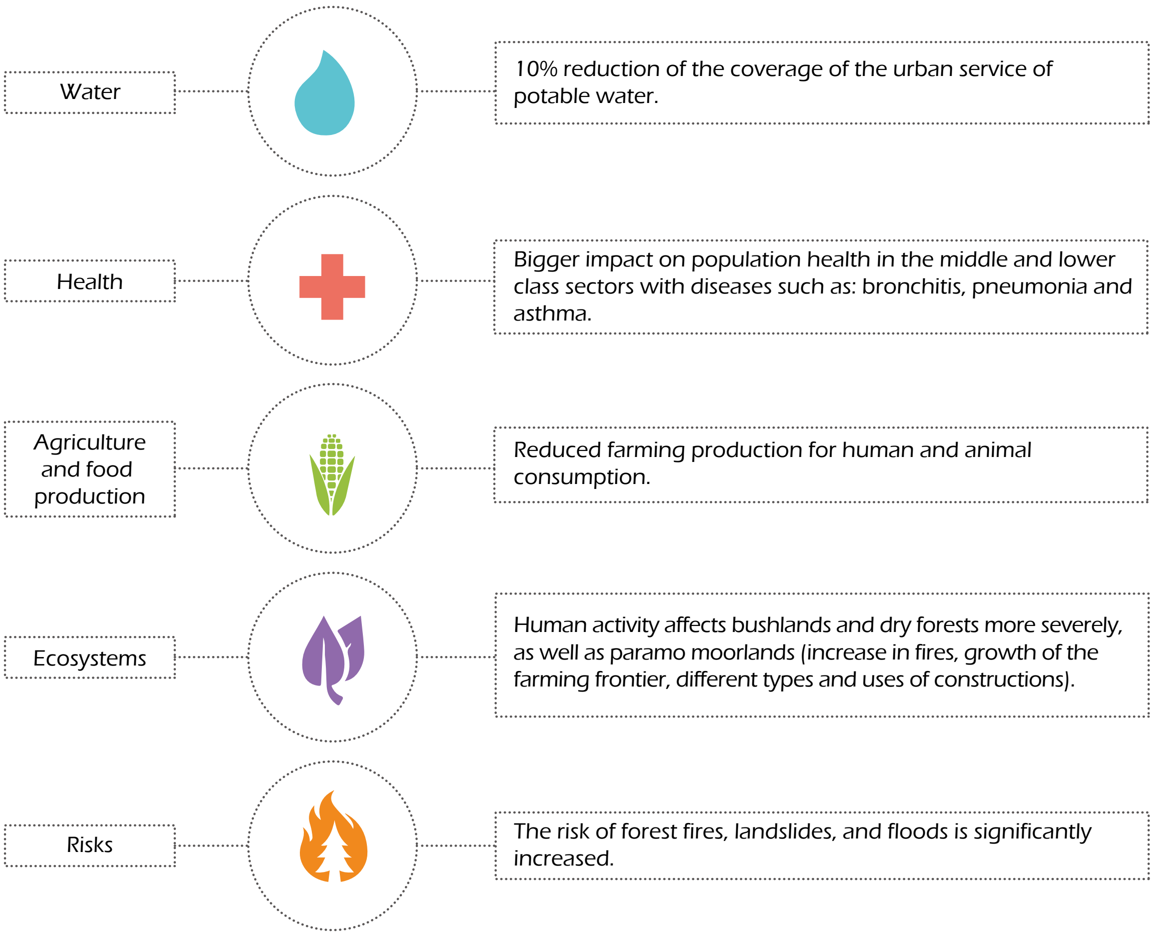
Fire risk sector

Expansion of the agricultural frontier, exploitation of natural forests for logging, and urban growth have drastically reduced the extent of natural forests in the country and have generated increasing pressure on land use, which has caused a decrease in the volume and reserves of water, causing problems in the availability of this resource for agricultural production, energy and domestic consumption (*Table 10*).

Involved in this process, forest fires are a major cause of environmental degradation. Traditionally, fire has been used to change land use from a forest to an agricultural profile. While the use of the slash and burn system has presently decreased, the use of fire in agricultural and livestock farming continues, and is a factor in the transformation of vegetation cover.

The periodic occurrence of forest fires is a change element in the natural conditions of the MDQ, and affects not only natural ecosystems but also adjacent ecosystems (forest plantations, agriculture, urban areas, transport networks, power lines, etc.) and society in different areas: human life and health, welfare, employment, economic and social activities, etc. (*Map 9*).

The natural scenery of the Metropolitan District of Quito is not free from the occurrence of forest fires, affecting the integrity of its natural resources. The summer of 2012 is classified as an extreme period due to the large number of fires and the area burned, exceeding the capacity of control agencies. In that year an emer-



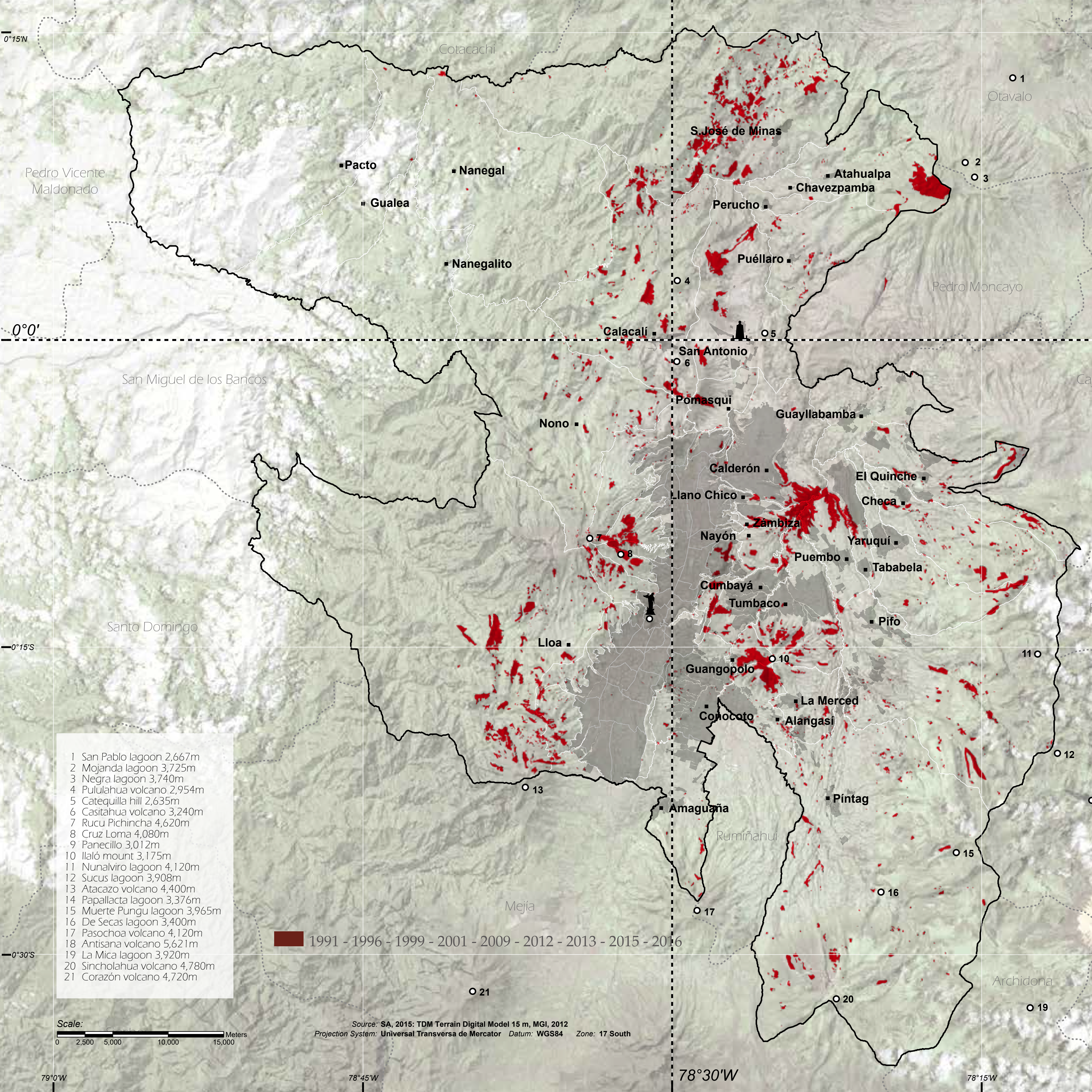
Infographic 15. Sectors vulnerable to climatic change by the year 2050 in the MDQ.
Source: Secretary of the Environment, Study of Vulnerability to Climatic Change, 2014.

gency declaration by the Municipal MDQ was necessary in order to increase budgets, equipment and activities to control and eliminate fires.

The MDQ's territory is one of the areas in Ecuador most affected by forest fires. Every summer the problem becomes acute and highlights the vulnerability of the district. There are 15 years of evidence showing an increased intensity and number of fires, particularly during the period 2001 to 2009. Furthermore, the year 2012 was marked by extreme and severe drought temperatures, factors that increased the intensity and frequency of fires and caused damage to protected areas of high biodiversity, to areas of public and private property with different uses, as well as having general effects on the welfare of the population.

The study of the MDQ's vulnerability to climate change is based on the following questions relevant to the sector: What are the areas where fire spreads the most? How are human actions related to the generation of fires? What is the effect of climate variability on the increase in fires?

Forest fire, Puembo 2015



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21 Corazón volcano 4,720m
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Source: SA, 2015: TDM Terrain Digital Model 15 m, MGI, 2012
Projection System: Universal Transversa de Mercator Datum: WGS84 Zone: 17 South
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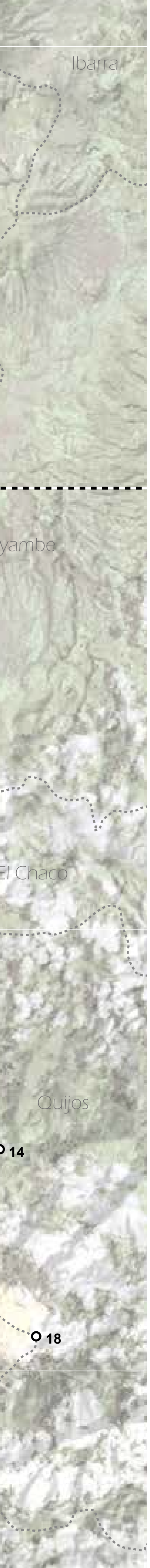
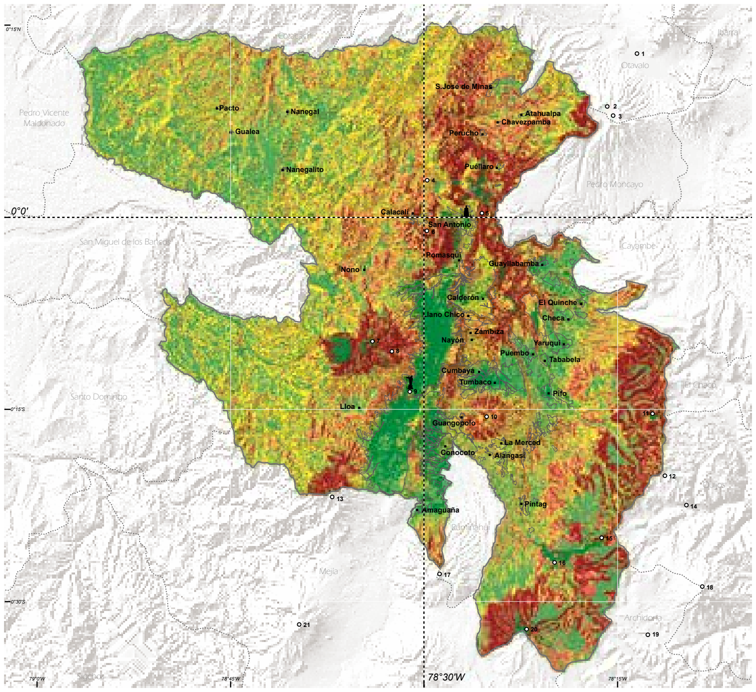


Map 9

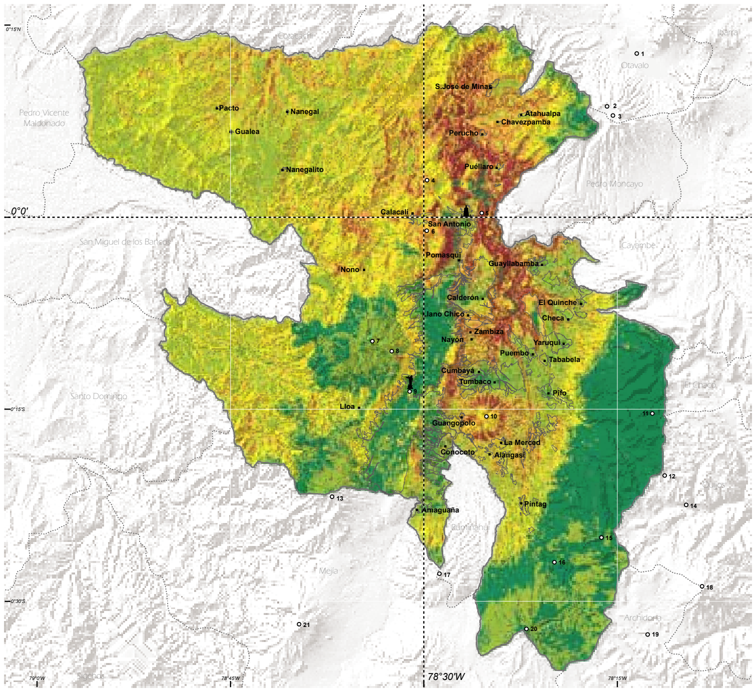
Occurrence of forest fires in the MDQ

Map 9a. Susceptibility to fires in the MDQ



Very high · High · Moderate · Low · Very low

Map 9b. Danger of forest fires based on four global climate prediction models, range: 1900 to 2015



Very high · High · Moderate · Low · Very low

Table 10. Vulnerability in the risk sector (forest fires) of the MDQ

Threats	Sensitivity Components	Exposure Factors or danger of forest fires	Vulnerability
In terms of the calculation of the pressure of the start of the fire: 1. Spatial indicator of the fire origin. 2. Historical indicator of the fire origin.	Two indicators of climate sensitivity have been used: 1. Indicator of rainfall pattern. 2. Indicator of thermic pattern.	Two variables have been considered: 1. Forest fire threat assessment 2. Susceptibility of vegetation cover to forest fires.	The MDQ possesses a tool to measure susceptibility to forest fires. Based on this, a forest fire susceptibility map has been created. The vulnerability study was complemented with a map of the risks or potential dangers of forest fires. In Map 9a, it can be observed that the MDQ is more at risk in areas with xerophytic vegetation and paramo moorlands. In Map 9b, it can be seen that the tendency of forest fire risk grows drastically in the outskirts of Quito, mainly in the east, in the driest areas of the MDQ.

Source: Secretary of the Environment, Study of Vulnerability to Climatic Change, 2014.

Ecosystems sector

While it is true that native ecosystems represent 60% of the territory of the MDQ, the accelerated growth of urban sprawl, among other socioeconomic factors, is exerting strong pressure on native ecosystems, vegetation cover and land use.

The Secretary of the Environment of the Municipal MDQ identified five types of ecosystems of particular interest, which are here evaluated: 1) dry scrub and relicts of dry forest, 2) paramo vegetation, 3) rain forests and forest plantations, 4) wet bush land, and 5) vegetation in the process of regeneration.

The study is based on the following relevant questions for the sector: What is the current vulnerability of the ecosystems of particular interest to non-climatic anthropogenic threats? What is the future vulnerability of the ecosystems of particular interest to the climatic threat of gradual increase in average yearly temperature?

The results for the ecosystems sector are shown in *Table 11* and *Map 10*.

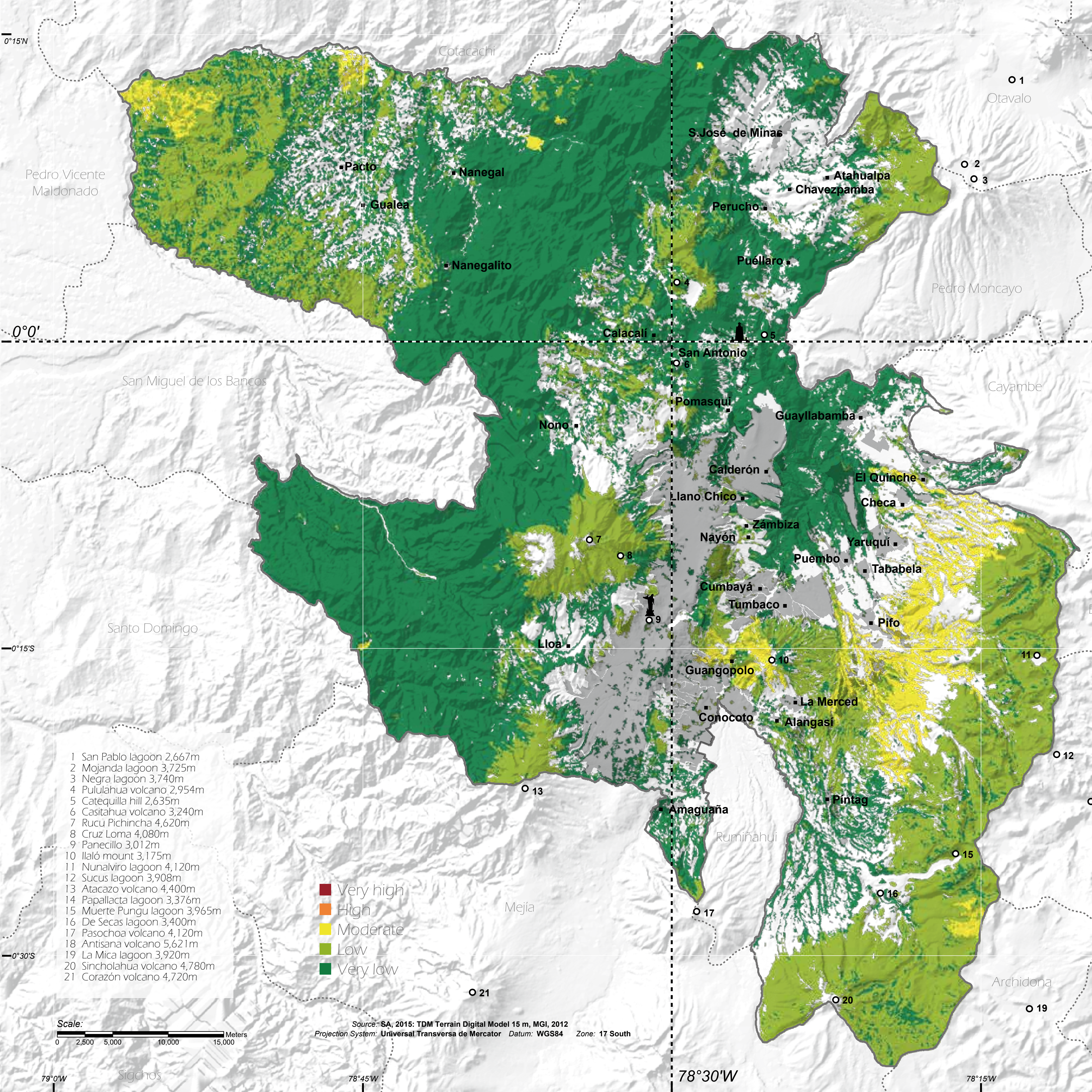
Table 11. Vulnerability in the ecosystems sector of the MDQ

Threats	Sensitivity Components	Exposure Factors	Vulnerability
1. Anthropic threats (implying the removal of vegetation cover): forest fires, expansion of farming areas, expansion of urban sprawl, road construction, pipeline/multiple pipelines construction and power lines outside urban areas. 2. Climatic threats: gradual increase of annual average temperature.	Sensitivity to anthropic and climatic threats.	Direct exposure (area destroyed or degraded by threats) and indirect exposure (area of influence adjacent to the threat).	The level of vulnerability was determined for five ecosystems: dry shrubland and relicts of dry forest, paramo moors, rainforests and forest plantations, wet bushland, and vegetation in the process of regeneration. These categories were selected for displaying higher anthropogenic pressure and are considered of particular interest by the Secretary of the Environment. The ecosystems most vulnerable to anthropic threats are: dry shrubland and relicts of dry forest. The ecosystem that is most vulnerable to climatic threats is paramo moorland.

Source: Secretary of the Environment, Study of Vulnerability to Climatic Change, 2014.

Photo: Pablo Lozano

Pressure of farming on the paramo moors of Atacazo.



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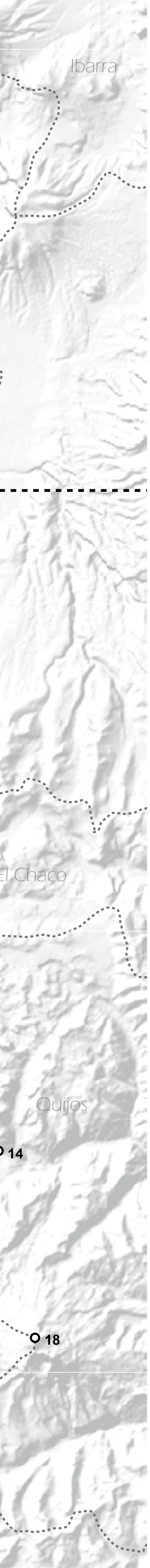
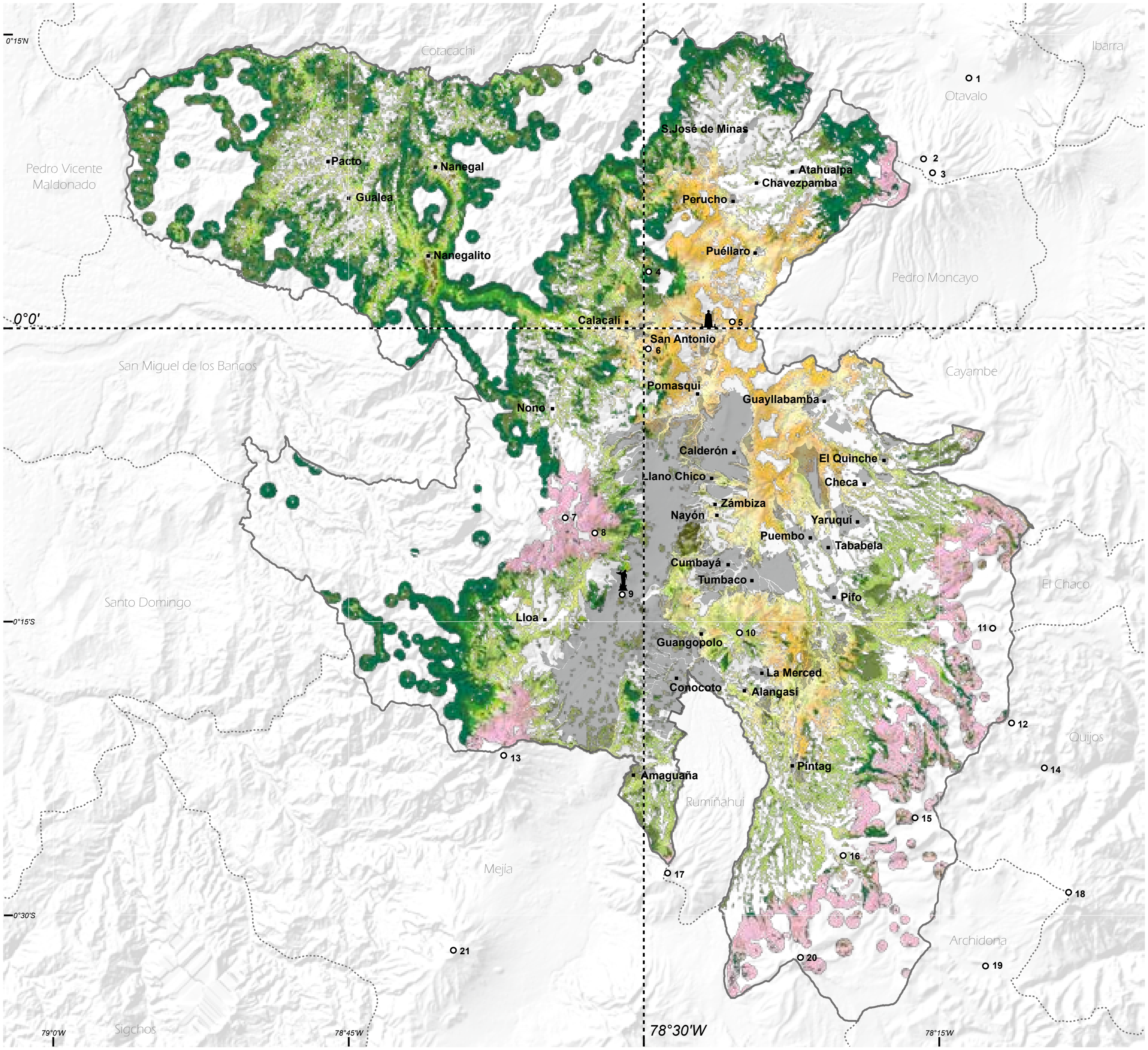


10 Map

Vulnerability of ecosystems to anthropic threats

Vulnerability of ecosystems to anthropic threats



- Rainforests and forest plantations, 1
- Rainforests and forest plantations, 2
- Rainforests and forest plantations, 3
- Rainforests and forest plantations, 4
- Rainforests and forest plantations, 5
- Dry shrubland and relicts of dry forest, 1
- Dry shrubland and relicts of dry forest, 2
- Dry shrubland and relicts of dry forest, 3
- Dry shrubland and relicts of dry forest, 4
- Dry shrubland and relicts of dry forest, 5
- Paramo vegetation, 1
- Paramo vegetation, 2
- Paramo vegetation, 3
- Paramo vegetation, 4
- Paramo vegetation, 5
- Wet shrubland and vegetation in the process of regeneration, 1
- Wet shrubland and vegetation in the process of regeneration, 2
- Wet shrubland and vegetation in the process of regeneration, 3
- Wet shrubland and vegetation in the process of regeneration, 4
- Wet shrubland and vegetation in the process of regeneration, 5

Agricultural sector

The study of vulnerability to climate change in the MDQ is based on the following relevant questions for the agricultural sector: What is the vulnerability of agricultural crops to climate change? What is the sensitivity of crops and how can they be affected during growth cycles by changes in temperature? How will climate variability affect crop exposure to changes in temperature, what will be the effect on crop growth and the agricultural frontier, thereby exposing the paramo moors to the changes in that frontier?

The results obtained for this sector are displayed in *Map 11*, and *Table 12* shows the distribution of agricultural crops in the MDQ and the vulnerability of these to climate change.

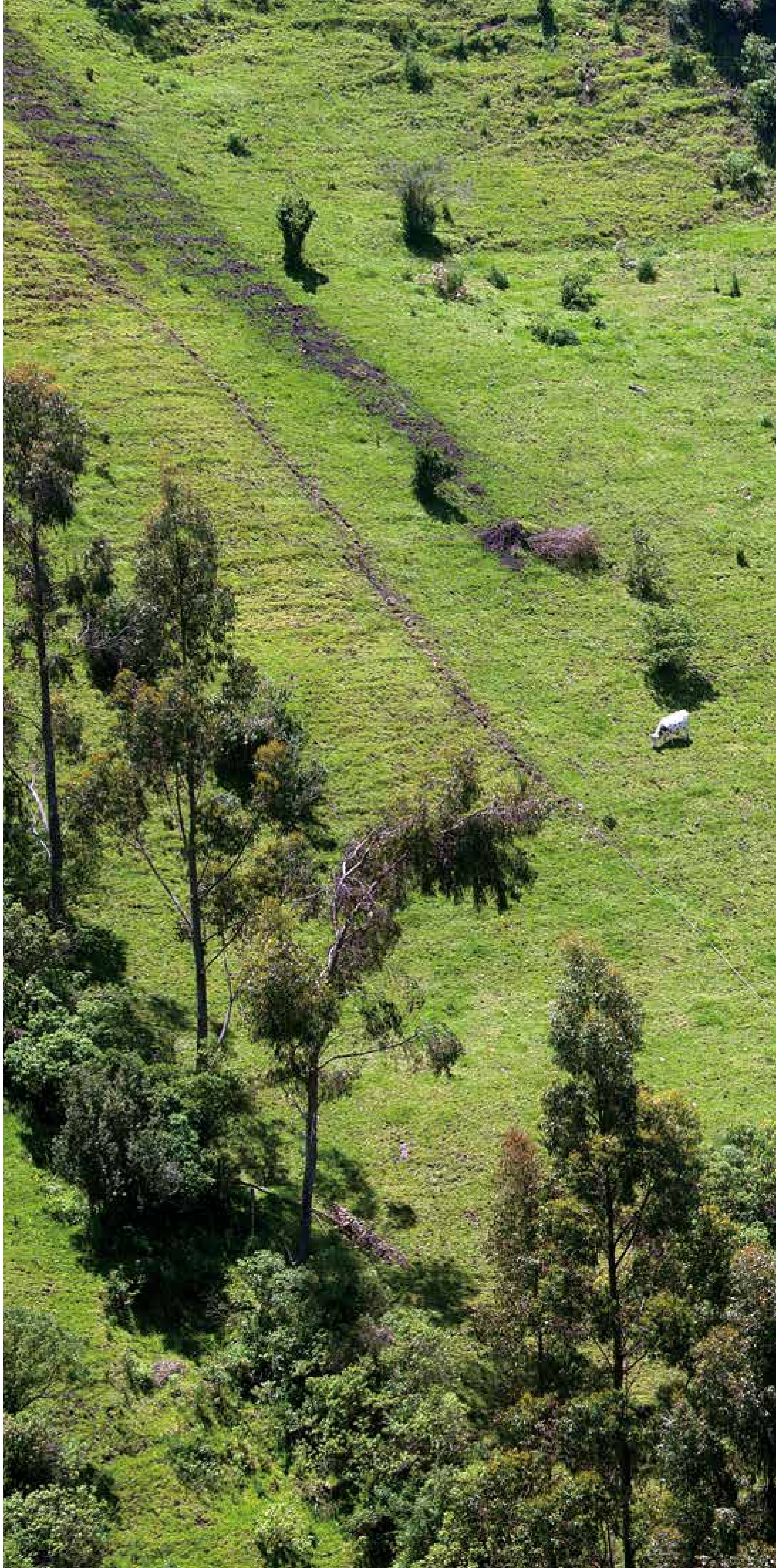
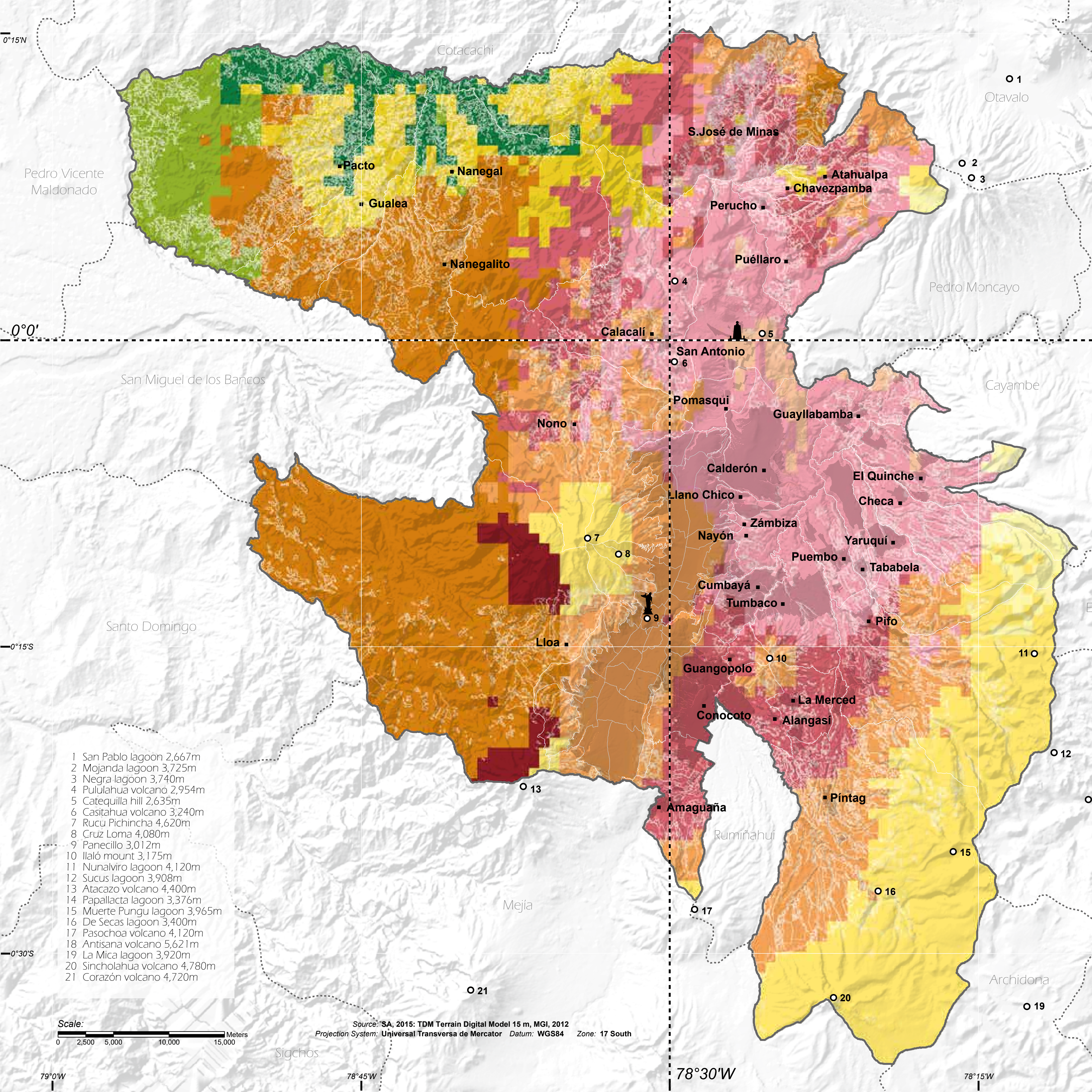


Photo: Secretary of the Environment

Pastureland, Lloa.



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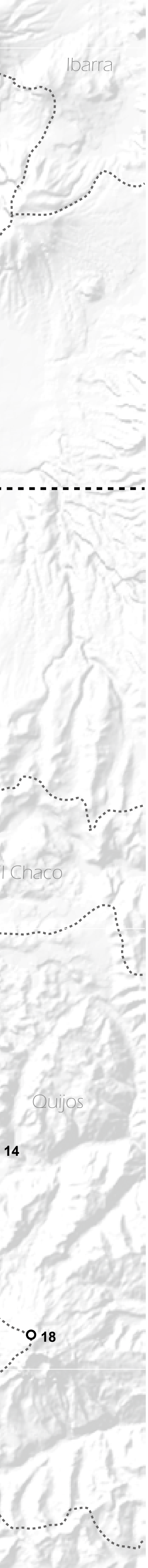
Projection System: Universal Transversa de Mercator Datum: WGS84 Zone: 17 South



11 Map

Crop cycle vulnerability in climatic regions

Photo: Martin Jaramillo

Urban gardens

Table 12. Vulnerability of the agricultural sector to climate change.

Sensitivity components	Exposure factors	Vulnerability
1. The sensitivity of crops to changes in temperature and the effect of these changes on growth and production: measured according to the assessment of stress due to temperature or growth reduction due to temperature. 2. Sensitivity of crop growth cycles to temperature changes: calculated according to heat units and their accumulation.	Increase in temperature	Determined according to sensitivity combined with the MDQ climatic regions and changes corresponding to the growth period. More vulnerable crops are: corn, broad beans, vegetables, fruits, potatoes and pasture.

Source: Secretary of the Environment, Study of Vulnerability to Climatic Change, 2014.

Sensitivity of crops to the increase in temperature.

Climate – Crop sensitivity - Precipitation - Temperature

- Very humid paramo - Very High - 2,285mm - 2,4ºC
- Semi-dry montane - Very High - 1,340mm - 2,4ºC
- Dry montane - Very High - 750mm - 2,4ºC
- Cultivated area
- Very humid montane - High - 2,460 mm - 2,3ºC
- Semi-humid montane - High - 1,360mm - 2,4ºC
- Very dry montane - High - 450mm - 2,4ºC
- Very humid tropical - Low - 3,030mm 2,3ºC
- Humid montane - Moderate - 1,715mm - 2,3ºC
- Humid paramo - Moderate - 1,430mm - 2,4ºC
- Dry paramo - Moderate - 900mm - 2,4ºC
- Tropical - Low - 1,580 mm - 2,3ºC

Water sector: supply

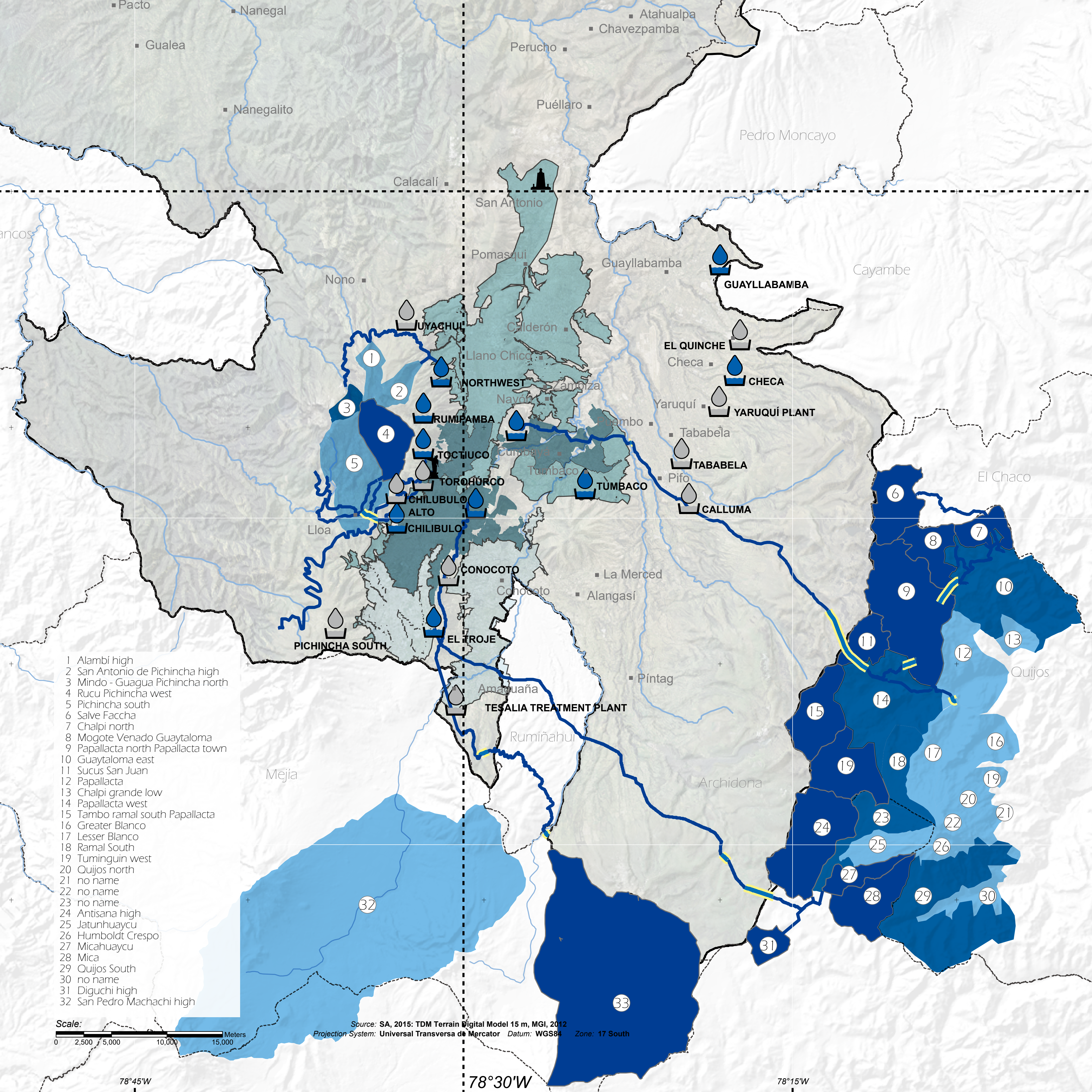
The vulnerability analysis of the water sector in the MDQ mainly consists of estimating the sensitivity and exposure of water sources for the supply of potable water to an estimated population of 2.4 million inhabitants.

The study of the MDQ's vulnerability to climate change considers two types of units for analysis: 1) water basins contributing 'raw' water, and 2) the potable water service areas. The analysis seeks to answer the following question relevant to the sector: How vulnerable is the potable water supply system in the MDQ in terms of current and future demand?

Considering the results of modeling in WEAP (Water Evaluation and Planning System) for the decade 2040-2050, in the most extreme scenarios (scenario 3 and 5) it is estimated that there will be a reduction of coverage in urban drinking water by 10%. This means that only 90% of demand could be met, hence the system is considered to be highly vulnerable. This statement is made under the assumptions made in scenarios 1 to 5 (*Map 12*) of this study: 1) population growth, 2) population growth and increased temperature, 3) population growth, increased temperature and prolonged periods of drought, 4) population growth, increased temperature and loss of paramo moors, 5) population growth, increased temperature, prolonged periods of drought and loss of paramo moors.

Photo: Anaís Córdova-Páez

Cambayá reservoir



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CALLUMA
CHILIBULO
El Chaco
Lloa
CONOCOTO
La Merced
Conocoto
Alangasí
PICHINCHA SOUTH
EL TROJE
Píntag
Quijos
Amaguaña
TESALIA TREATMENT PLANT
Rumiñahui
Mejía
Archidona
1 Alambí high
2 San Antonio de Pichincha high
3 Mindo - Guagua Pichincha north
4 Rucu Pichincha west
5 Pichincha south
6 Salve Faccha
7 Chalpi north
8 Mogote Venado Guaytaloma
9 Papallacta north Papallacta town
10 Guaytaloma east
11 Sucus San Juan
12 Papallacta
13 Chalpi grande low
14 Papallacta west
15 Tambo ramal south Papallacta
16 Greater Blanco
17 Lesser Blanco
18 Ramal South
19 Tuminguin west
20 Quijos north
21 no name
22 no name
23 no name
24 Antisana high
25 Jatunhuaycu
26 Humboldt Crespo
27 Micahuaycu
28 Mica
29 Quijos South
30 no name
31 Diguchi high
32 San Pedro Machachi high
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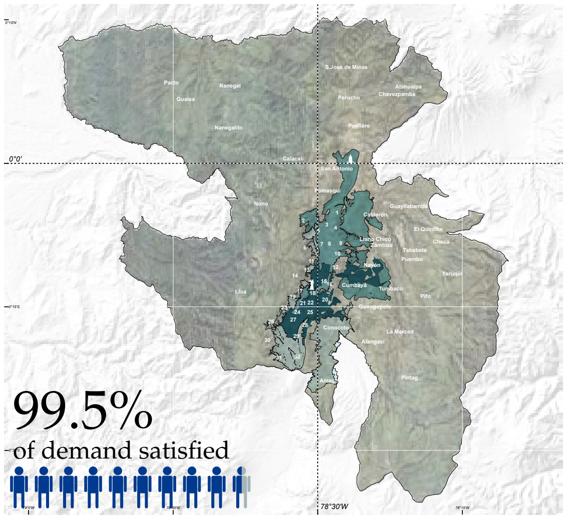
12 Map

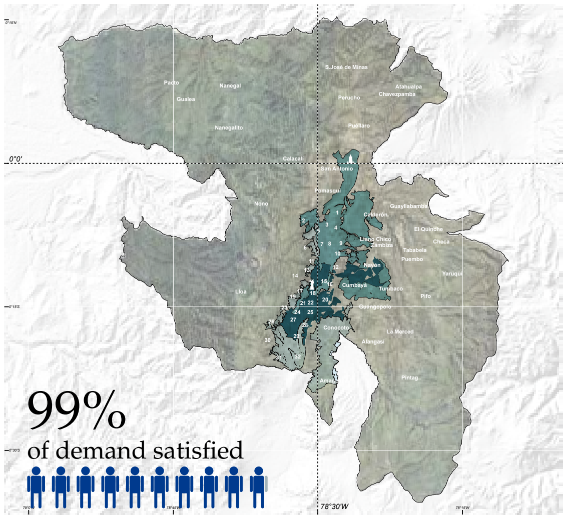
Vulnerability of potable water supply to 2050

Scenarios of potable water cover to 2050

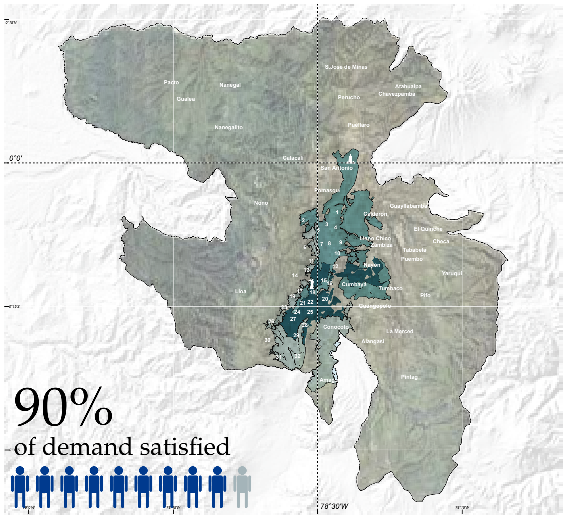
Scenario 1:
Population growth



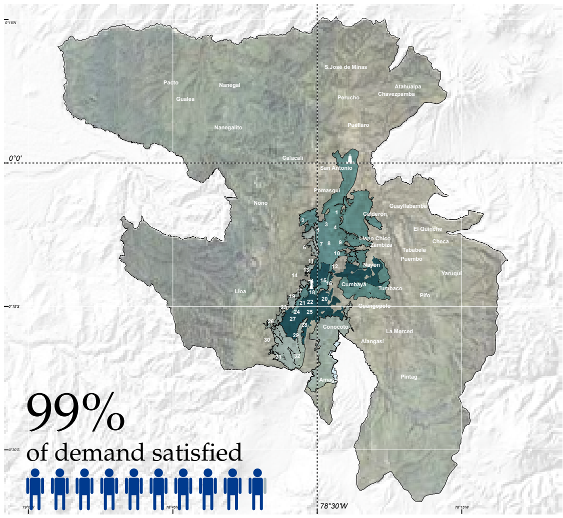
Scenario 2:
Population growth- Increased temperature



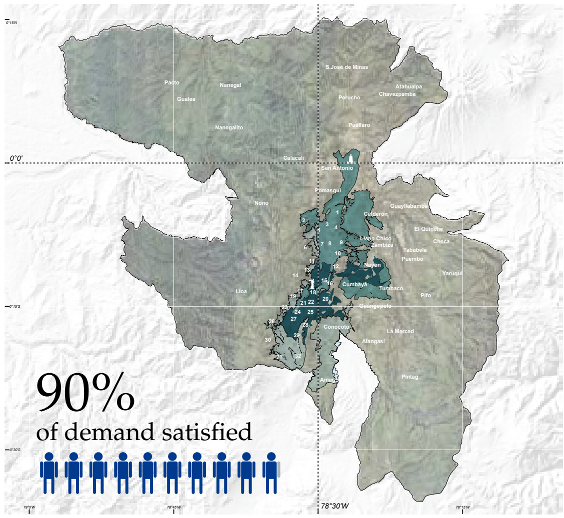
Scenario 3:
Population growth- Increased temperature
Prolonged periods of drought



Scenario 4:
Population growth - Increased temperature
Loss of paramo moors



Scenario 5:
Population growth -Increased temperature
Prolonged periods of drought - Loss of paramo moors

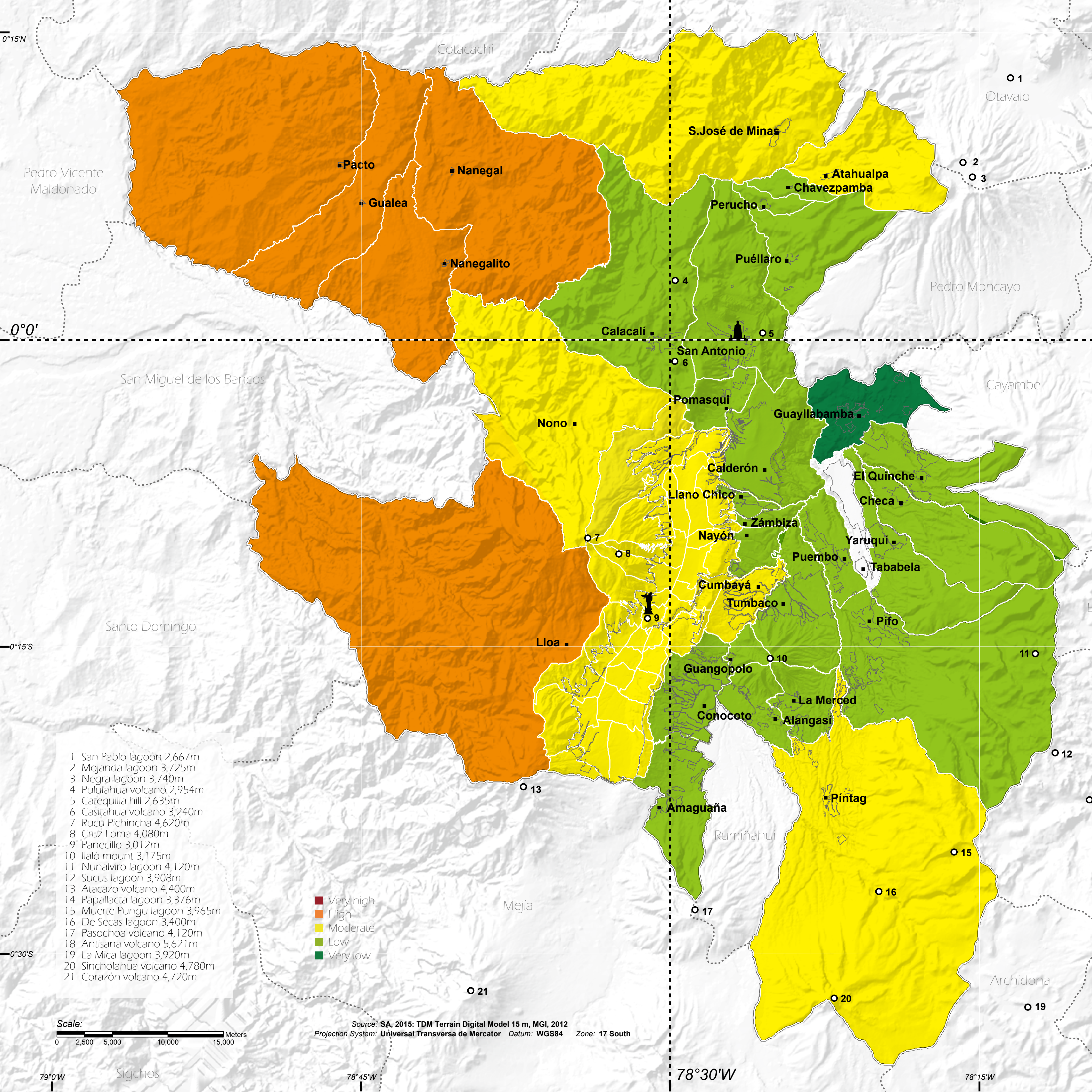


Water basins contributing potable water
Decrease in precipitation to 2050
- Less than 6 mm
- 6 - 15
- 15 - 25

Potable water service areas
Coverage percentage 2050
- High
- Moderate
- Low

Treatment plant
Water type
- Raw
- Treated

- Potable water pipe
- Potable water tunnel



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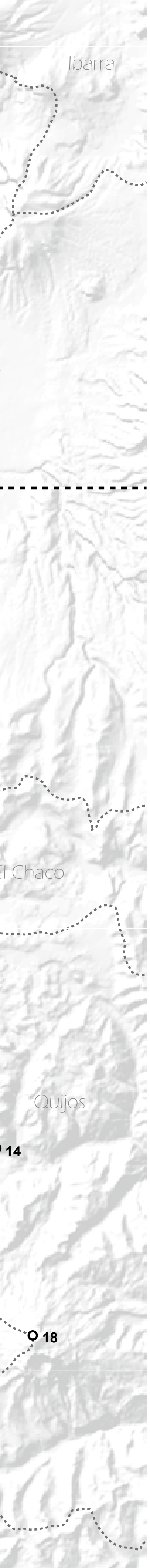
Calacalí
San Antonio
Pomasqui
Guayllabamba
Nono
Calderón
Llano Chico
El Quinche
Checa
Zámbiza
Nayón
Yaruquí
Puembo
Tababela
Cumbayá
Tumbaco
Pifo
Lloa
Guangopolo
La Merced
Conocoto
Alangasí
Amaguaña
Píntag
1 San Pablo lagoon 2,667m
2 Mojanda lagoon 3,725m
3 Negra lagoon 3,740m
4 Pululahua volcano 2,954m
5 Catequilla hill 2,635m
6 Casitahua volcano 3,240m
7 Rucu Pichincha 4,620m
8 Cruz Loma 4,080m
9 Panecillo 3,012m
10 Ilaló mount 3,175m
11 Nunalviro lagoon 4,120m
12 Sucus lagoon 3,908m
13 Atacazo volcano 4,400m
14 Papallacta lagoon 3,376m
15 Muerte Pungu lagoon 3,965m
16 De Secas lagoon 3,400m
17 Pasochoa volcano 4,120m
18 Antisana volcano 5,621m
19 La Mica lagoon 3,920m
20 Sincholahua volcano 4,780m
21 Corazón volcano 4,720m
Very high
High
Moderate
Low
Very low
Scale:
0 2,500 5,000 10,000 15,000 Meters
Source: SA, 2015: TDM Terrain Digital Model 15 m, MGI, 2012
Projection System: Universal Transversa de Mercator Datum: WGS84 Zone: 17 South



Map 13

Vulnerability of the Health Sector in the MDQ

Health sector

The study of vulnerability to climate change in the MDQ was based on the following questions relevant to the health sector: What is the vulnerability of the population to various diseases in a climate change situation? What diseases affecting the population of the MDQ have a close relationship with climatic variables? What role is played by socioeconomic conditions and the prevalence of diseases in the framework for analyzing vulnerability to climate change in the health sector? How are the three types of variables considered in the analysis interrelated?

During the study the Health Sector Vulnerability Index in the MDQ was calculated in relation to respiratory diseases (bronchitis, pneumonia and asthma), as there is empirical evidence of a correlation between these diseases and climatic variables such as precipitation, humidity and temperature (*Map 13*).

To perform this calculation an integrated model combining socioeconomic variables, statistics on hospital discharges and climatic variables was developed, in a methodological approach for determining vulnerability in terms of sensitivity, exposure and climate threat.

The results show large differences between the vulnerability indexes of the different parishes of MDQ, with ranges between 1 (very low) and 4 (high). The most vulnerable parishes are located in the northwestern part of the MDQ owing to the fact that socioeconomic conditions in these areas are medium-low and the parishes are located in areas where the rate of climate threat is high in relation to the occurrence of respiratory diseases. Meanwhile, the urban area of Quito has a moderate vulnerability index which could increase to high in the event that extreme weather events become more frequent in the future as a result of climate change.

It is important to analyze the results of the vulnerability index in an integrated manner. Less vulnerable parishes are located in the eastern part of the MDQ, which will begin to generate development poles in the coming years. In these areas there is a benevolent climate in relation to respiratory diseases and the socioeconomic status of the population is medium-high. For this reason economically and environmentally sustainable productive projects should be fomented in these areas, with the aim of increasing the socioeconomic conditions of the population. In this way low rates of sensitivity and vulnerability in the overall population may be maintained.

Part III
TOWARDS A SUSTAINABLE CITY

An environmentally responsible city grows in accordance with the national and rational limits of its terrestrial and water ecosystems. Such a city considers and plans its territory taking environmental assets into account, thus minimizing negative impacts that generate pollution, it conserves and uses its natural resources and biodiversity in a sustainable manner reducing risk levels, and is resilient to the effects of climate change. Its functioning is based on alternative energy and mobility motivating citizens to use public spaces in a manner which stimulates collective wellbeing and quality of life for its citizens. Arias Verónica 2016.

Photo: Anaís Córdova-Páez

View of Gonzalez Suarez Street reflected in a pond

WHAT IS SUSTAINABLE DEVELOPMENT?

Humanity faces the challenge of ensuring coexistence on the planet, creating a space where there is a future for all forms of life, cohabiting in an equitable and sustainable manner over time. It is unthinkable to consider a process of human development without taking into account the natural context, the environment.

Reconciling the satisfaction of current and future human needs with the need to maintain the balance of biophysical systems so that harmonious relations between society and nature are established is now essential. Today the challenge is greater because the Earth is facing the most dangerous anthropogenic global environmental phenomenon of this age: climate change.

Since the 1970s, scientists have realized that natural resources are finite, that the planet's capacity to support life has limits and that economic growth threatens the survival of humanity. People then began to address environmental issues from different areas, interrelating aspects such as politics, demographics, energy and food, to create projections for the coming years. At the same time, work has intensified in the interpretation of the problems related to development and the environment, as well as changes in the implicit concepts of these terms.

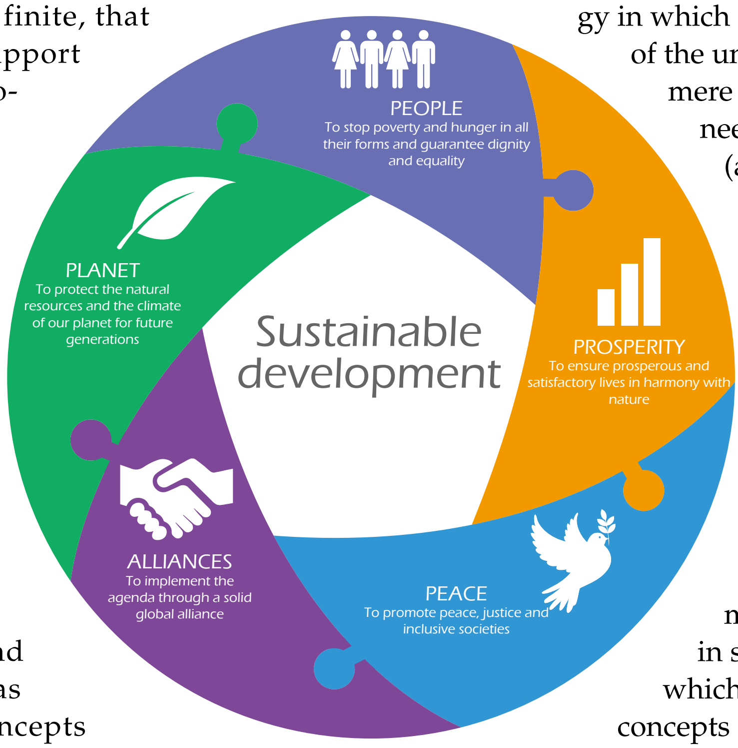
To date, efforts have focused on raising awareness among politicians and leaders on the world stage about the fragile state of the planet.

Analysis has deepened our understanding of the interdependence between the environment, society, the economy and politics, of the need to take future generations into account and to implement socially and culturally diverse and inclusive policies and strategies, to extend analysis towards a holistic and systemic thinking of sustainability, in which a good life for all beings on Earth is paramount, while promoting education as the main tool to empower people in relation to sustainable development.

The long-term balance of these factors constitutes the fundamental idea of sustainability, for which there is no single, fully accepted definition. The concept is still evolving as it continues to incorporate new elements (*Infographic 1*).

This concept has gone from being an ideology in which the human being is the center of the universe and where nature is a mere object serving only to meet the needs and interests of humanity (anthropocentric vision), to a philosophy that integrates and respects all the components of the universe and the Earth, acting on behalf of social justice, in which human beings are part of nature and everything is interconnected (ecocentric vision).

Table 1 displays a number of relevant facts and documents, internationally validated in spaces for UN decision-making, which explain the evolution of the concepts of sustainability and sustainable development:



Infographic 1. Elements of sustainable development.
Source: UN, 2015

Evolution of the concepts of sustainability and sustainable development

Year	Event	Instrument	Description
1972	Meadows Report or 'Limits to Growth' (Club of Rome)		Models the possible consequences of maintaining economic growth long-term; based on the hypothesis that if the rates of world population growth, industrialization processes, pollution levels, and natural resources exploitation are maintained, absolute limits of World growth will be reached during the coming years.
1972	Stockholm Conference on the Human Environment (UN)		• Officially recognizes the 'contemporary ecological crisis' • For the first time, 'sustainable development' is discussed as a process by which natural resources are preserved for present and future generations.
1982	Bruntland Report or 'Our Common Future' (World Commission on Environment and Development - UN)		The concept of 'sustainable development' becomes a global and integrated ethic recognizing environment protection as the basis for long-term economic and social development.
1992	Rio Conference on Environment and Development or the 'Earth Summit' (UN)	Rio Declaration	• The right to sustainable development is explicitly declared and based on the balanced relationship between the environment, society, the economy and governance. • The environmental principles of precaution and prevention and the right to access (information, participation and justice) are established.
		Agenda 21	• Plan of global action to promote sustainable development • "Local authorities (…), in their capacity as the closest authorities to the people, play an extremely important function in people's education and mobilization in favor of sustainable development".
		Convention on Biological Diversity	Objectives: Achieve the conservation of biological diversity, the sustainable use of its components, and the fair and equitable distribution of the profits from the use of genetic resources.
		United Nations Framework Convention on Climate Change (UNFCCC)	Objective: Stabilize greenhouse-effect gases in the atmosphere to prevent alterations in the climatic system; allow ecosystems to naturally adapt themselves to changes; ensure that food production is not threatened; allow economic development to continue in a sustainable manner.

Table 1. Evolution of the concepts of sustainability and sustainable development

Year	Event	Description
2000	Millennium Development Goals (MDGs) - 'Millennium Summit' (UN)	Eight global goals adopted for accomplishment by 2015, aimed at: eradicating extreme poverty and hunger; achieving universal primary education; promoting gender equality and women's empowerment; reducing child mortality; improving maternal health; fighting HIV/AIDS, malaria and other diseases; ensuring environmental sustainability; promoting a global partnership for development.
2002	Johannesburg Conference on Sustainable Development (UN)	Reaffirms the concept of sustainable development and adds new elements to enrich it, such as cultural diversity, universal peace, solidarity and human dignity.
2012	'The Future We Want' - Rio+20 Summit (UN)	Establishes inputs to promote sustainable development in search of a 'green economy' to combat poverty and stop environmental degradation due to climate change, desertification and loss of biodiversity.
2015	The 2030 Agenda for Sustainable Development - Sustainable Development Summit (UN)	17 Sustainable Development Goals (SDGs) are established with 169 targets to be reached by 2030 to transform the world for people, the planet and prosperity, by reinforcing universal peace and the global partnership for sustainable development.

Photo: Secretary of the Environment

Dr. Mauricio Rodas, Mayor of the Metropolitan District of Quito and Veronica Arias, Secretary of the Environment. Smart and Sustainable Cities Forum.

UN 2030 Agenda for Sustainable Development

Goals of the objectives of sustainable urban development

During the New York Summit in September 2015, the UN General Assembly approved the 2030 Agenda for Sustainable Development, which raises 17 overall objectives and 169 goals calling all countries to action.

These Sustainable Development Goals (SDGs) seek to eliminate extreme poverty, combat inequality and injustice and protect the environment, within a framework of global sustainable development. They have a comprehensive focus and were constructed through consultation processes worldwide, with the participation of local authorities, communities, civil society, networks, international organizations and the private sector; it is hoped that implementation of the objectives will also be participatory. The role of cities and local authorities is crucial in implementing the SDGs, and in particular the urban objectives (*Infographic 2* and *Table 2*).

As they are crucial for sustainable development and urban management for the quality of life in cities, the SDGs had an important role in the climate change negotiations held in December 2015 in Paris, as well as posing great challenges to the international agenda, in particular for the third United Nations conference on housing and sustainable urban development, Habitat III, the venue for which will be Quito in October 2016.

Paris Agreement COP21

In December 2015, during the Twenty-First Conference on Climate Change (COP21) in Paris, the UN General Assembly approved a final agreement that is expected to enter into force in 2016.

The main points of the agreement are:

- For the first time, the agreement is legally binding for all signatories.
- The countries agreed to strive so that by end of the century the Earth's temperature does not rise more than 1.5°C compared to the preindustrial era (circa 1850).
- The agreement includes limiting the amount of greenhouse gases (GHGs) emitted by human activity (mitigation).
- Similarly, concrete actions for adaptation to the changes already taking place in the climate were sought, to increase the resilience of the population.
- The contribution of each country in reducing emissions will be reviewed every five years, so that reductions can be incremented over time.
- On financing, although the text does not mention specific amounts, developed countries pledged to provide about 100 billion dollars annually from 2020 to developing countries, thus helping them to reduce their emissions and implement projects to address climate threats.

Despite this historic agreement, scientists and activists have been strongly critical because according to their perspective the key to halting global warming lies in taxing emitters of greenhouse gases.

The Metropolitan District of Quito has actively participated in the sustainability agenda of conferences on climate change, including COP21 in Paris, by providing important inputs and contributions through the major international networks.

SUSTAINABLE DEVELOPMENT GOALS

17 GOALS TO TRANSFORM OUR WORLD

No poverty
End poverty in all its forms everywhere

Zero hunger
End hunger, achieve food security and improved nutrition and promote sustainable agriculture

Good health and well-being
Ensure healthy lives and promote well-being for all people at all ages

Quality education
Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

Gender equality
Achieve gender equality and empower all women and girls

Clean water and sanitation
Ensure availability and sustainable management of water and sanitation for all

Affordable and clean energy
Ensure access to affordable, reliable, sustainable and modern energy for all

Decent work and economic growth
Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

Industry, innovation and infrastructure
Build resilient infrastructure, promote inclusive sustainable industrialization and foster innovation

Reduced inequalities
Reduce inequality within and among countries

Sustainable cities and communities
Make cities and human settlements inclusive, safe, resilient and sustainable

Responsible consumption and production
Ensure sustainable consumption and production patterns

Climate action
Take urgent action to combat climate change and its impact

Life below water
Conserve and sustainably use the oceans, seas and marine resources for sustainable development.

Life on land
Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation and halt biodiversity loss

Peace, justice and strong institutions
Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

Partnerships for achieving the goals
Strengthen the means of implementation and revitalize the global partnership for sustainable development

Infographic 2. Sustainable Development Goals
Source: UN-Habitat, 2015

Table 2. Proposed targets of the urban sustainable development goals.

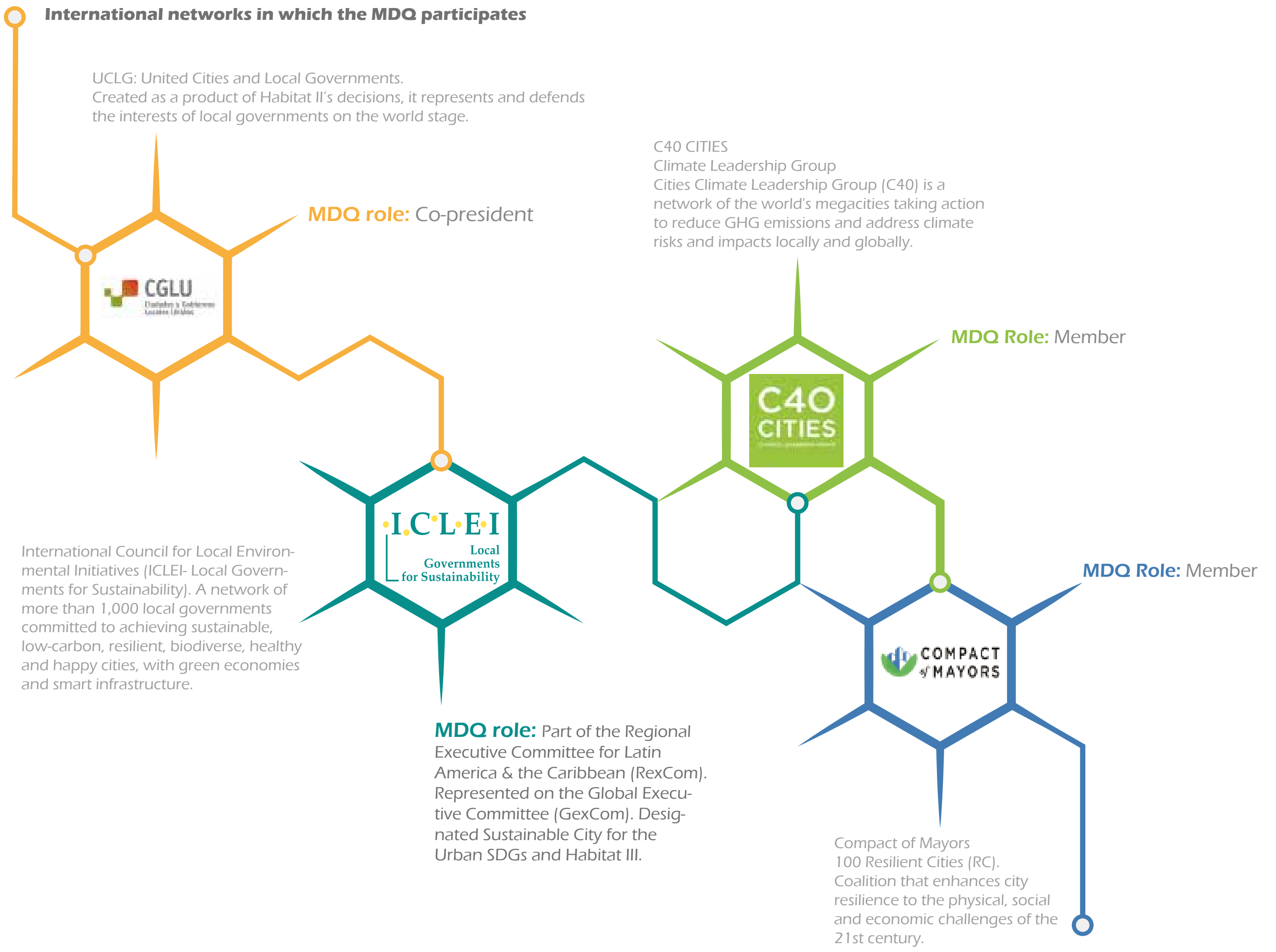
By 2030: ensure access for all to adequate, safe and affordable housing and basic services, and upgrade slums.
By 2030: provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.
By 2030: enhance inclusive and sustainable urbanization and capacities for participatory, integrated and sustainable human settlement planning and management in all countries. Strengthen efforts to protect and safeguard the world's cultural and natural heritage.
By 2030: significantly reduce the number of deaths and the number of people affected, and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations.
By 2030: reduce the adverse per capita environmental impact of cities, by paying special attention to air quality and municipal and other waste management.
By 2030: provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning.
By 2020: substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels. Support the least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials.

Source: UN, 2015. Elaborated by: Vanessa Gutierrez, Secretary of the Environment, MDQ

MDQ LEADERSHIP IN SUSTAINABILITY AND CLIMATE ACTION

To connect the dots between the implementation of SDGs and the mitigation of climate change, cities must integrate low-emission strategies in each sector of planning and urban development.

For some years, the Metropolitan District of Quito has played an active role in several international networks, as it participates in and supports the construction of global agendas. Membership of these networks has helped the city to position itself internationally and promote the exchange of experiences and technical assistance for building a sustainable future. *Infographic 3* highlights some of these networks.



Infographic 3. International networks in which the MDQ participates.
Source: Un-Habitat, 2015

428 cities, representing 5.19% of the world population, have pledged themselves to the Compact of Mayors. Quito is one of the 45 cities in the world (one of six cities in Latin America) to achieve full compliance.

Through the various initiatives of these networks, the MDQ has shown international leadership, empowerment and commitment to achieving the SDGs in the fight against climate change and the construction of the New Agenda for Sustainable Urban Development towards Habitat III.

On the subject of climate change, it is important to highlight the historical initiative of the Compact of Mayors, founded in September 2014 during the UN Climate Summit by the UCLG, ICLEI and C40 networks. Taking into account that 70% of global GHG emissions come from urban areas, the Compact of Mayors is an agreement between the member cities of these networks to provide a transparent and solidary approach to reducing emissions at the citizen level, in order to reduce vulnerability to climate change and build resilience in a manner consistent with and complementary to climate protection efforts made at national level (*Infographic 4*).

In September 2015, the Municipal MDQ joined the Compact of Mayors. After three months, full compliance with this initiative was achieved by meeting all required criteria. To do this, Quito pledged to reduce its emissions and to be resilient to the climate. Regarding mitigation measures, the Municipal MDQ, through the Secretary of the Environment, has developed an inventory of GHG emissions according to the methodology of the GPC[1], established goals to reduce emissions and developed a mitigation plan, incorporated into the Municipal Territorial Management Plan 2015-2025. In relation to adaptation measures, the plan identified climate threats to the MDQ, created a vulnerability analysis and developed an adaptation plan, the Climate Action Plan 2012-2016.

Infographic 4. Completed Phases of the Compact of Mayors
Source: UN-Habitat, 2015

1 GPC – Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories

THE UNITED NATIONS HUMAN SETTLEMENTS PROGRAM: UN-HABITAT

Mayors and their counterparts in different cities are becoming the principal political leaders in response to the challenges facing the planet.

In the 1960s, the impacts of urbanization were barely considered by the international community. However, the world witnessed an uncontrolled increase in urban populations, provoked largely by migration to cities which left rural areas depopulated and in extreme poverty, as well as by natural population growth resulting from advances in medicine.

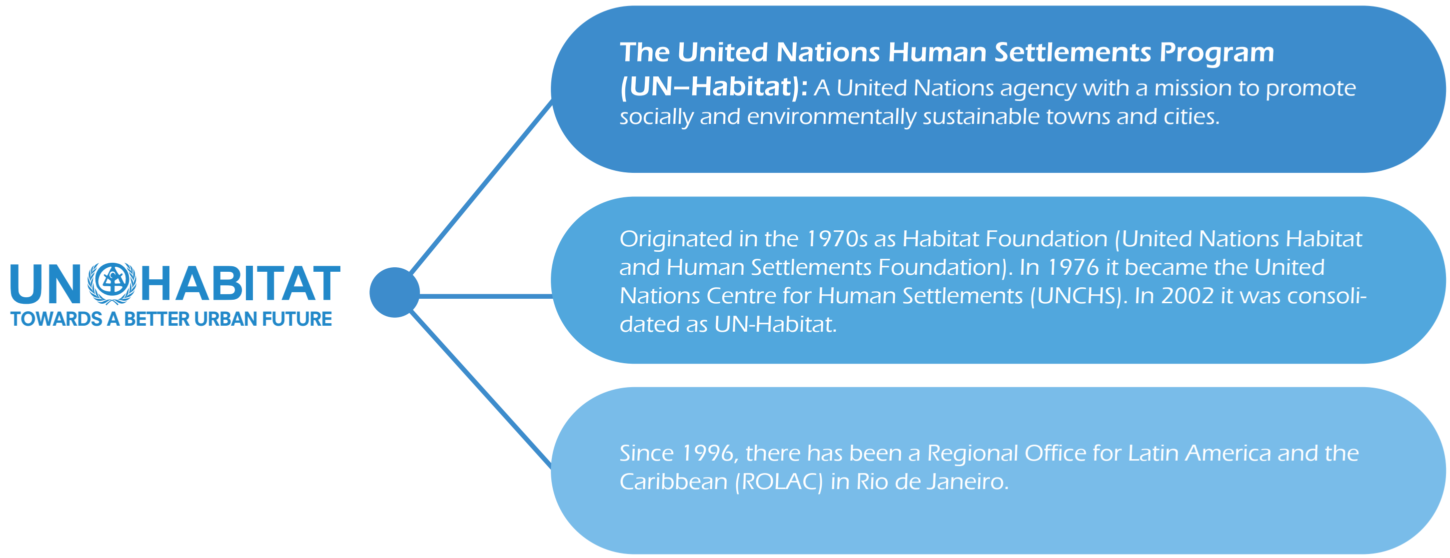
Governments have demonstrated the negative effects of rapid and unplanned urbanization, particularly in developing countries, resulting in the growth of so-called 'illegal settlements', subject to frequent forced evictions and leading to a dramatic human situation.

Faced with this problem, governments set out to examine the processes of urbanization in order to mitigate these conflicts at local level, leading urban authorities to take into account the aspects specific to each territory.

In this historical context, in 1973 the United Nations General Assembly stressed the urgent need for action on a global scale to protect and improve the quality of life in human settlements, and resolved to deliver the first United Nations Conference on Human Settlements in 1976 (UN, 1973).

At that time governments recognized the magnitude and consequences of rapid urbanization from the perspective that the unacceptable circumstances of human settlements would likely worsen with economic growth and uncontrolled urbanization, without positive and concrete measures at national and international levels.

From that point, for over forty years the United Nations Human Settlements Program (UN-HABITAT) has been working with human settlements around the world, focusing the process of urbanization in the development of the villages, towns and cities most in need of support. It has also developed an integrated methodology based on a new vision that incorporates



Source: UN-Habitat, 2015

Port-Au-Prince, Haiti. Google Earth 2014. UN Human Settlements Program.

three essential elements for sustainable urbanization: urban regulations, urban planning and design, and municipal finances. Thus, UN-HABITAT supports governments and local authorities in the promotion of an integrated approach to the planning and construction of sustainable cities and urban settlements to achieve greater public awareness and improve the participation of local populations, including the poor, in the decision-making process (UN-HABITAT, 2015). *Table 3* shows an overview of the Habitat Conferences.

1976	1996	2016
Habitat I	**Habitat II**	**Habitat III**
First United Nations Conference on Human Settlements (Habitat I) **Vancouver, Canada** 'Adequate housing and basic services are a basic human right'.	Second United Nations Conference on Human Settlements, 'City Summit' **Istanbul, Turkey** "Cities for a more sustainable future"	Third United Nations Conference on Housing and Sustainable Urban Development **Quito, Ecuador** 'Sustainable Cities'
Global urban population: 37.9% Governments recognized the need for sustainable human settlements and the consequences of rapid urbanization, especially in the developing world. **Objective:** To develop strategies to control and reduce the magnitude of the urbanization process and promote strategies to minimize rural-to-urban migration by people in search of better life conditions. **Vancouver Declaration and Action Plan** • Human settlements as a development tool and goal. • The need to elaborate development and territorial management plans and strategies that adapt to local realities in order to ensure the provision of basic services and a better redistribution of resources for urban and rural areas. • The coordination of national governments with regional decentralized autonomous governments and the private sector was not prioritized.	**Global Urban population:** 45.1% Important stimulus from the Earth Summit of 1992: The adequate management of human settlements was recognized as a pre-requisite to reach the general goals of sustainable development. **Objetive:** To combat poverty and upgrade substandard housing with special attention to human settlements in risk areas. **The Istanbul Declaration and the Habitat Agenda (global plan of action for adequate housing for all):** • Cities are the engines of global growth • Urbanization is an opportunity • Calls for a more prominent role for local authorities • Recognition of the power of participation Creation of UCLG as an organization giving cities and local governments a voice before the UN.	**Global urban population (World Bank, 2014):** 53.4% **Objetive:** To determine guidelines for building equitable, prosperous, safe and sustainable cities, in order to reinvigorate the global commitment to achieving sustainable settlements, focusing on the implementation of a 'New Urban Agenda'.

Table 3. Short historical overview of the Habitat Conferences.

Source: UN-Habitat, 2015

Habitat III: Housing and sustainable urban development

Sustainable cities

In accordance with its twenty year cycle (1976, 1996 and 2016), the United Nations General Assembly has convened through resolution 66/207 the Third Conference on Housing and Sustainable Urban Development, Habitat III, in order to revitalize the global commitment to sustainable urbanization.

Habitat III, to be held in Quito from the 17th to the 20th of October 2016, seeks to define the New Urban Agenda for Sustainable Development, based on the lessons learned from the implementation of the Habitat II Agenda from 1996 and the Millennium Development Goals from the year 2000. Thus, the conference's objectives are to secure renewed political commitment for sustainable urban development, assess the achievements to date, address the issue of poverty, and identify and assume new and emerging challenges.

"While significant progress has been made in implementing the Istanbul Declaration on Human Settlements and the Habitat Agenda (...), challenges remain, such as urban sprawl, congestion, pollution, the emission of greenhouse gases, emerging urban poverty, segregation, increasing inequalities and other negative externalities, as well as the continuing increase in the number of slum dwellers in the world, the negative impact of environmental degradation, including climate change, desertification and loss of biodiversity, on human settlements and the need to reduce disaster risks and build resilience to disasters in urban settlements" (UN, 2014).

It is expected that Habitat III will begin debates on the planning and management of cities, towns and villages, in consideration of the new challenges posed by the 2030 agenda for sustainable development.

There is also the expectation that the New Urban Agenda will incorporate the commitments of the Paris Agreement resulting from COP21. Cities and local authorities definitely have an increasingly important role in the fight against climate change, and Habitat III is a great opportunity to demonstrate leadership and empowerment in finding local solutions.

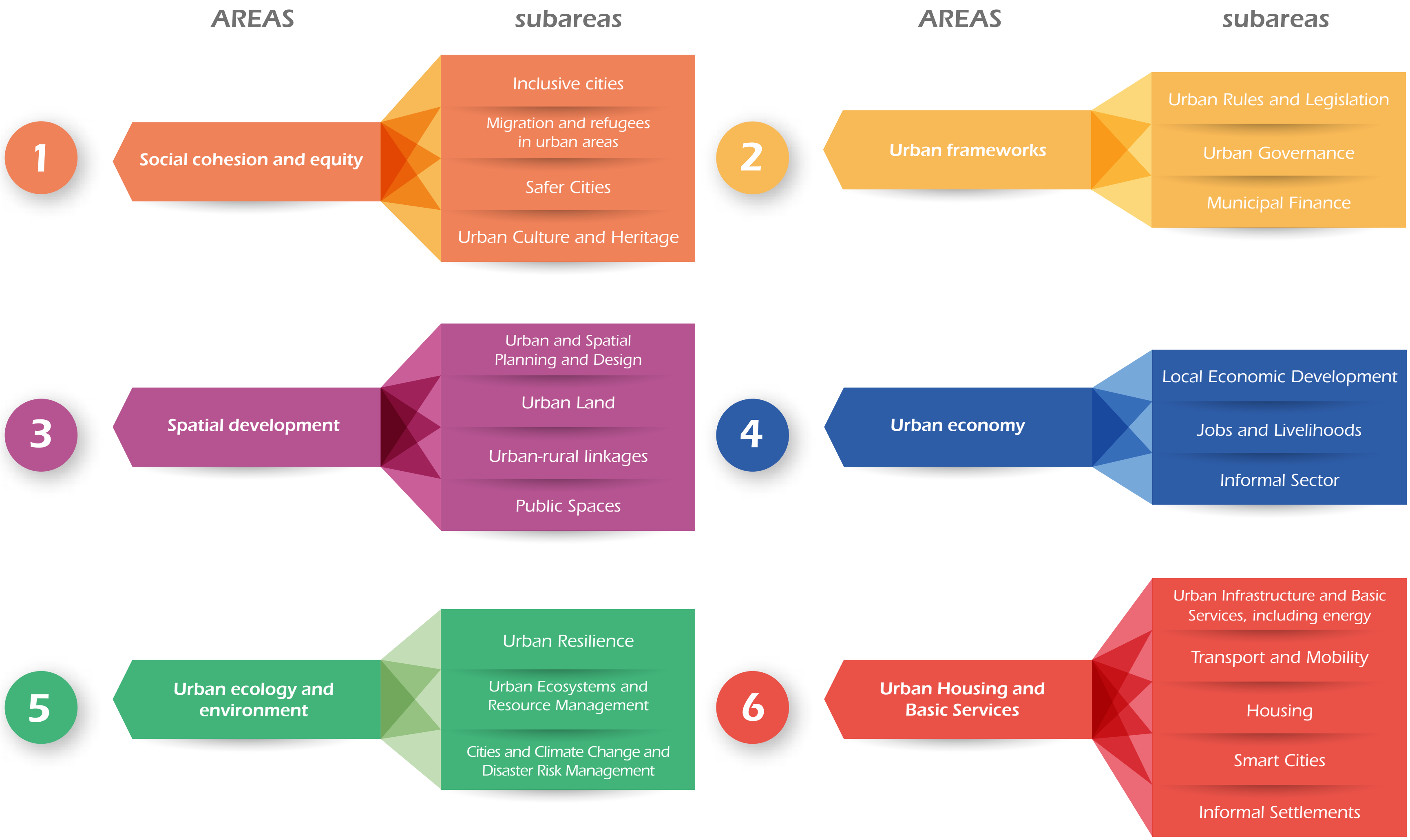
Urban problems are many and cannot be treated in isolation. That is the biggest challenge for the construction of the New Urban Agenda. In the last 20 years much progress has been made in implementing sectoral policies on housing, health, mobility and sustainability. However, the perception is that these issues have not yet been articulated and integrated into the international agenda, and Habitat III constitutes an opportunity for discussion of the main challenges and the development of common solutions focusing on a broader view of local needs.

The New Urban Agenda intends to contribute towards successfully addressing the sustainable urban development challenges faced by governments through national and local policies, constructed using a process of public participation involving all sectors of society (*Infographic 5*).

Vision of a sustainable city

Sustainable development management of urban areas is critical to the quality of life of our peoples (UN, 2015).

The New Urban Agenda to be defined in Habitat III seeks to achieve sustainable cities. To this end, the General Assembly of the UN invited governments to formulate and implement "policies for sustainable urban development that promote fair, resilient and inclusive cities, and that for this purpose, take into account the contributions of all relevant stakeholders, with special emphasis on the needs of women and the most vulnerable, including children and young people, the elderly, people living with disabilities, people who migrate



Infographic 5. Thematic structure of the New Urban Agenda of Habitat III
Source: UN-Habitat, 2015

from rural to urban areas, IDPs (Internally Displaced Persons) and indigenous peoples" (UN, 2014).

One of the main purposes of sustainable urban development should be to build cities for people, where citizens meet and interact in public spaces and participate in social processes. We should aim to create safer, healthier, vibrant and attractive cities to live in, where there is a good public transport service and spaces for both pedestrians and cyclists are promoted (IDB, 2014).

To achieve sustainable cities, local authorities should adapt environmental planning and management to an urban context addressing pressing environmental issues such as air pollution, water quality, the management of solid waste, urban traffic and climate change. Mechanisms for 'innovative participation' and 'environmental governance' are highlighted together with the promotion of natural and sustainable economic and social development, in the hope of achieving greater environmental awareness and institutional cooperation.

A sustainable city is one that optimizes agglomeration economies, promotes sustainable density, fosters social and cultural diversity, optimizes land use and promotes public spaces; as such becoming a functional city, but maintaining environmental balance.

A sustainable city provides less expensive basic services such as access to potable water and sanitation, achieving increased resilience to climate change.

Urbanization, considered in the context of sustainability, requires a constitution that permits the creation and feasible application of a sustainable urban development pattern based on a set of rules and regulations.

As a complement to the above, for good municipal management and maintenance it is indispensable to have municipal financial systems that, among other functions, equitably redistribute urban revenues created, and cease their role as instruments of income generation to become conduits for change, generating concrete results in terms of development.

Quito, Metropolitan District, seeks to be a sustainable city through the implementation of strategies contained in the Metropolitan Development and Territorial Management Plan 2015-2025, which was constructed based on the results of several sustainability indicators.

SUSTAINABILITY IN RELATION TO URBAN DEVELOPMENT OF THE MDQ

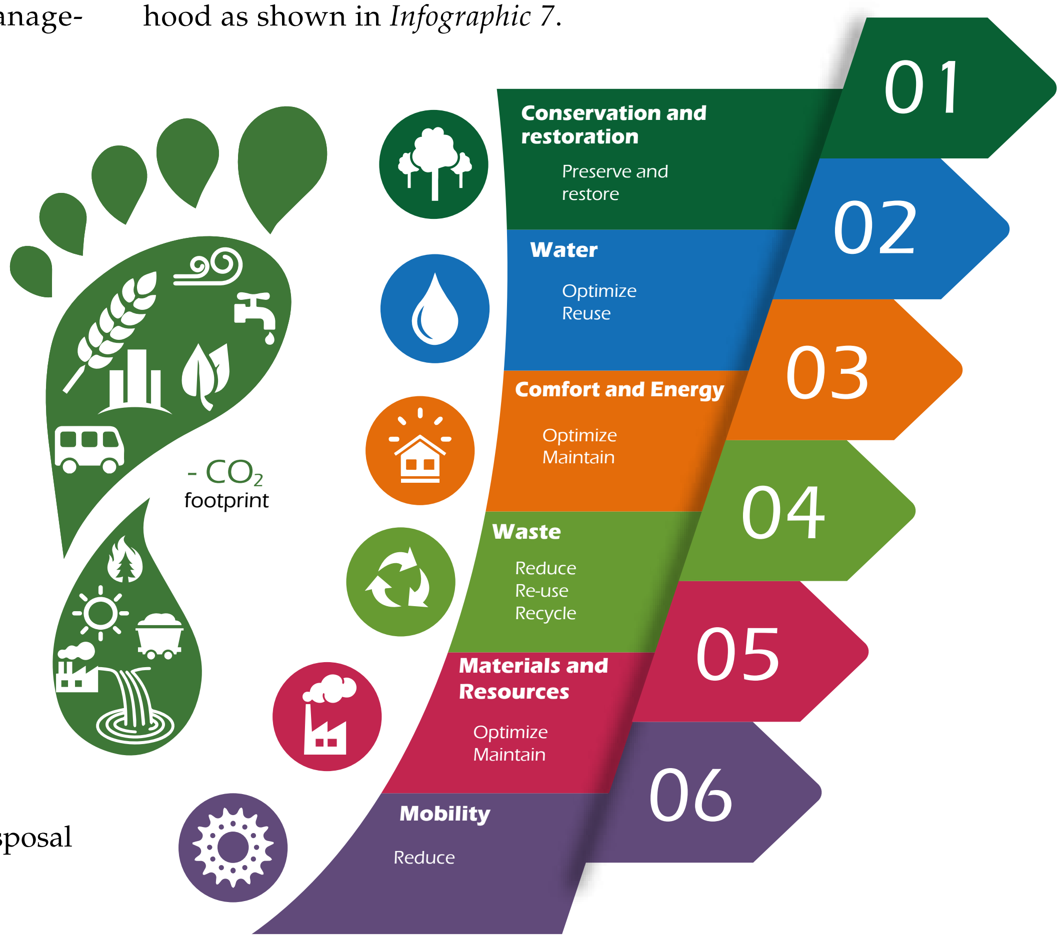
Environmental criteria for sustainable construction

"Quito, sustainable city is the proposed vision for local environmental management as a right and a duty of all Quitenians, who will be part of the solution through the incentivization and recognition of the participation of citizens, local actors and a diversity of organizations, thus providing the basic structure for sustainable territorial development" (Metropolitan Development and Territorial Management Plan, 2015).

Under this proposal, environmental criteria are developed in a context of coordinated planning articulated by architectural urban progress towards developing an inclusive, secure, resilient and prosperous city, contributing to a residential, commercial and industrial urban approach with services and green areas for public and private use, reducing environmental impacts and improving the quality and warmth of life for citizens. Environmental components that contemplate these criteria are:

- Conservation and restoration of the environmental landscape.
- Use and efficiency of consumption of water and energy.
- Treatment of solid and liquid waste.
- Use of renewable and reusable building materials.
- Provision of construction materials and disposal of debris.
- Increased public spaces and green areas for public and private use with alternative mobility facilities.
- Reduction of the CF in construction.

The development of these criteria requires large-scale Special Urban Architectural Projects with significant environmental impacts to improve the urban scheme, evaluating performance during construction and operation, minimizing the environmental impact of pollution and the loss of ecosystems, and fulfilling the integral sustainability requirements of "reduce, conserve and maintain", which are quantified and recorded by measuring the footprint of construction and operation of the building, thus promoting regenerative city processes (*Infographic 6*). An example of this is the San Carlos neighborhood as shown in *Infographic 7*.



Infographic 6. Environmental criteria for sustainable construction.

The state of conservation and restoration of the environment

The overall perception of the site for project deployment epitomizes the state of conservation and restoration of urban and rural environments, showing evidence for efficient construction and the reduction of impacts on biodiversity, water, soil, air and noise, as well as consideration of the degree to which sensitive areas are threatened with damage and the need for restoration of degraded areas. The analysis of this criterion focuses on:

- Prioritization of conservation areas and restoration of native and/or exotic vegetation cover existing in ravines, hillsides, wetlands or adjacent sites with rich natural habitat and scenic beauty.

- Articulate the urban green network with its natural environment.

Water use and efficiency

The reduction, treatment and reuse of water is an overriding goal of sustainability that every designer, manufacturer and supplier should consider to keep a balance between the supply, demand and quality of water resources[2], safeguarding the health of people and ecosystems, and favoring soil permeabilization[3]. This criterion focuses its analysis on:

- Reusing existing water flows such as canals, irrigation ditches, wetlands and reservoirs which provide support to mountain streams and rivers.
- Designs for sidewalks, flower beds, roads, parking lots and parks, which maximize soil permeabilization.
- Treatment of black water and sludge (waste from toilets, urinals), and gray water (washbasins, showers and sinks), which can be used for the irrigation of indoor gardens.
- Harvesting of usable rainwater for the irrigation of orchards, gardens, communal green areas, and recirculation for use in toilet plumbing and fire control systems.
- Efficiency of bathroom fixtures: showers, toilets and faucets for low consumption and recycling.

Energy efficiency and comfort

The location and orientation of the building envelope provides the architectural basics for implementing systems for saving and using clean alternative energy, which provide comfort in relation to temperature, light, ventilation and noise within the building. This criterion focuses its analysis on:

- Orientation of the building envelope in order to optimize thermal comfort, integrating the use of natural light, ventilation, exterior view, shadow effect and reflection control.
- Application of control devices for indoor and outdoor lighting.

Waste management (3Rs)

Efficiency in Integrated Waste Management involves community processes for reduction, reuse and recycling of solid waste[4], which should be designed with consideration for the following criteria: signage, accessibility (ve-

2 Article 6, Resolution 002 of the Secretary of the Environment, Technical standard for the control of liquid discharges containing parameters with limits for wastewater discharges.
3 Metropolitan Ordinance No.282: Use, rehabilitation and maintenance of sidewalks, maintenance of facades and enclosures, and preservation of urban public woodland.

4 Ordinance 332, Solid Waste Management, 2014

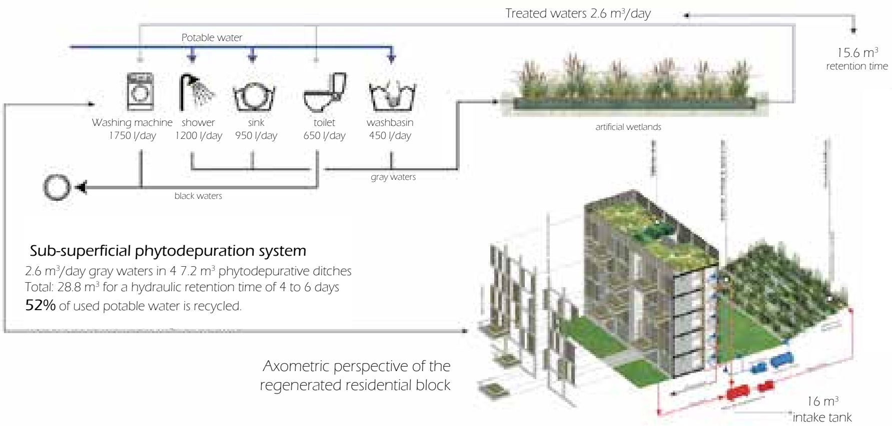
Infographic 7. Academic Proposal for regeneration: the San Carlos Housing Plan

Integrated proposal of consolidated urban transformation and regeneration that diversifies the use and exploitation of green areas, promotes alternative mobility, and improves housing conditions creating a compact, mixed and cohesive area.

Present state of the original residential block.

Source: Thesis project FADA-PUCE, Mauricio Mesias.

Water use and efficiency



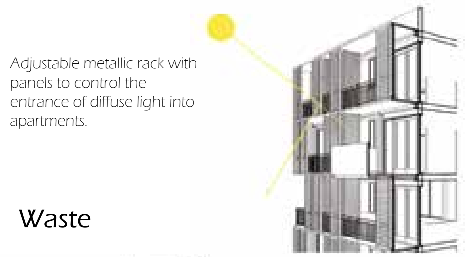
Mobility

Pedestrian and Public transportation network

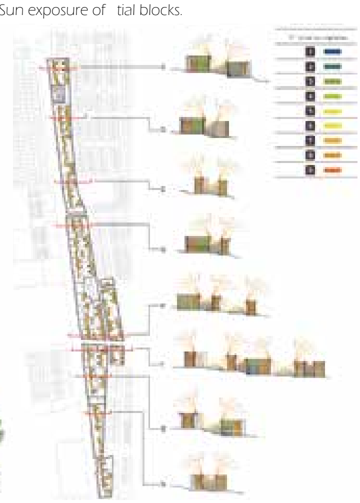
Mobility

Pedestrianization of Pedro de Alvarado Street

Energy efficiency and comfort



Sun exposure of   tial blocks.



Waste

Materials and Resources

Internal collection points for recyclable materials

Conservation and restoration of the surrounding environment

Green areas network

hicular and pedestrian), security (differentiated and recycling containers) and sites for engagement with qualified managers. This criterion focuses its analysis on:

- Integrated construction waste systems incorporating processes for the collection, separation and transport of waste during construction (wood, glass, concrete, iron, asphalt, etc.).
- Integrated domestic inorganic waste system incorporating processes for the collection, separation, reduction, reuse, recycling and exploitation of solid waste (plastic, paper, cardboard, bottles, etc.).
- Community programs for the management of non-hazardous organic and inorganic waste.

Materials and Resources (MR)

This is related to the increased use of environmentally friendly building materials under the concept of sustainability, as well as to the disposal of debris:

- Implementation of terraces and green walls in buildings by selecting recycled covering and finishing materials that are more resistant and deteriorate less when exposed to the elements.
- Designs that minimize impacts on the landscape.
- Use of long lasting building materials, the components for which come from ecological processes, recycled or reused, and purchased locally if possible.

Mobility (MOB)

Establishes the creation of public and private spaces allowing for alternative mobility facilities that enable connectivity and access to public mobility systems.

- Incorporation of bicycle parking areas.
- Implementation of bus stations with roofing, lighting and information about routes and timetables.

Carbon Footprint Projection

This enables the calculation of the carbon footprint (CO_2eq emissions) for possible carbon reduction measures during the construction phase of buildings[5].

For the calculation of the carbon footprint the MDQ's Secretary of the Environment proposes an emission factor of greenhouse gases according to local level construction activities, which will be referred to as an indicator for square meter of construction (CO_2eq/m^2 of construction).

Developers can calculate their direct carbon footprint in the construction phase as well as the aforementioned indicator for comparison with the emission factor. If this indicator exceeds the emission factor measures to reduce emissions should be proposed.

5 Ordinance 041, Metropolitan Development and Territorial Management Plan 2015-2025, Secretary of Territory Habitat and Housing.


Panoramic view of central Quito

Photo: Drone & Gis

The meaning of green in the city and public spaces

The importance of green in the city, understood as urban nature, lies in its positive effects on citizens. As part of the construction of cities for people, this section intends to highlight the significance of green in the city, mainly in public spaces, for its contribution to the environment, but also in recognition of the social, economic and heritage values that contribute to improving the quality of life, health and social cohesion of citizens and, consequently, to the positive perception of public spaces. Green spaces are considered to be 'essential' by the World Health Organization (WHO) due to the benefits derived from the physical and emotional well-being of people and to their help in mitigating the urban deterioration of the city, making it more livable and healthier. Green symbolizes a balanced city environment (*Infographic 8*).

- **Environmental values** contribute to the generation of favorable microclimates encouraging prolonged use of public spaces. The coverage of green areas has a fundamental role in the environment and the city's biodiversity. They affect people's metabolism and generate feelings of thermal comfort, acoustic comfort, and the general well-being related to environmental quality and public health. There are technical strategies for intervention in public spaces in order to mitigate the effects of island heat and solar radiation, to prevent risks of flooding and landslides, for the implementation of urban natural barriers for control of acoustics and prevailing winds, and as thermal and air quality regulators. These strategies will be discussed later.

- **Economic values** provided by greenery in the city consist of making urban parks and green areas visible as spaces for the development of economic enterprises, and the general value of greenery as a factor for increasing capital.

  Green areas and urban parks can introduce a role of productive entrepreneurship into the city, such as the implementation of urban gardens, which have demonstrated several benefits with respect to the urban landscape and the use of public spaces. Urban gardens promote small-scale self-sufficiency, healthier agricultural products, household savings, and social consciousness and cooperation. Urban gardens vindicate the principles on which sustainability and the 'green economy' are based.

  Urban parks also serve as platforms for the development of various forms of economic organization, such as the Popular and Solidary Economy legislated by Organic Law in Ecuador since 2011.

  On the other hand, it is known through several sources that urban greenery in neighborhoods increases the value of properties. Most people think that neighborhoods with trees are attractive places to live. This demand of the population in search of places with nature has increased home values in comparison with those other places lacking greenery (Kitchen & Hendon, 1967; Correll et al, 1978; Morales, 1980; Morales et al, 1983; Anderson & Cordell, 1988; Dwyer et al, 1992).

- **Social values** result in generating social cohesion and quality of life for citizens, as they affect people psychologically thus producing a sense of comfort and security.

  As in the case of economic values, encouraging the use of public spaces causes a high pedestrian flow that helps to improve security, and studies claim that substantial social ties have reduced levels of vandalism and crime (Brunson et al, 1998).

Infographic 8. The meaning of green

Photo: Martín Jaramillo

El Ejido Park

As cited in the text '*Benefits of urban woodland*', in 1999 Kuo and Sullivan found that in homes in areas with the highest rate of woodland, the rate of domestic violence was lower than for identical houses with a low or no presence at all of trees, "residents in homes with trees are usually more constructive, and have lower patterns of violence and intra-family conflicts" (Carlos P. González, 2002). Moreover, the authors argue that a neighborhood with strong bonds of unity, associated with a high rate of woodland, creates conditions of nonviolence and serves as a solution to conflict and frustrations.

Urban greenery also provides substantial benefits for mental health, labor welfare, in reducing pressure and stress, and contributes to physical and mental rehabilitation. It has been shown that patients in hospitals in rooms with exterior panorama views of trees and vegetation recover significantly faster and with fewer complications than patients in sites without such characteristics (Ulrich, 1984).

Furthermore, green areas and city parks generate spaces for leisure and recreation, are scenarios for sport and social relationships and foster symbolic activities for the city. Nature also inspires creativity and artistic and cultural production, and when there is a strong link with urban nature, this contributes to environmental awareness and encourages the practice of habits favoring the environment through the comprehensive understanding of the benefits to people's quality of life.

- **Heritage values** imply placing a high value on the scenic uniqueness possessed by territories to contrast between natural elements (mountains, rivers, ravines, greenery) and urban elements full of history and identity.

The consolidated city of Quito is situated on a plateau, bordered to the east by a series of hills such as Puengasí, Guanguiltagua and Itchimbía, and to the west by Atacazo and the massif of Pichincha that, in turn, consists of three volcanic elevations: Guagua Pichincha, Rucu Pichincha and Cóndor Guachana. In the city center the Yavirac hill, now known as the Panecillo, rises. This elevation joins the aforementioned others as elements identifying the city of Quito, forming the immediate landscape of the city and serving as reference points to determine north-south-east-west orientation; they have allowed inhabitants to position themselves geographically and define routes since pre-Hispanic times.

This unique composition was recognized when Unesco declared Quito to be the first World Cultural Heritage Site in November 1978, not only for its historical center, but also for its scenic value. The declaration signaled: "The city of Quito forms a unique ensemble sui generis where nature and man are brought together to create a work unique and transcendental of its kind".

It is important to highlight that the geographical composition of the city means the landscape incorporates mountainous bodies located to the east, among these are: the Puntas hill and Cayambe, Ilaló, Antisana and Cotopaxi volcanoes.

A strong bond with natural heritage is part of the local identity. For example, the mountain streams, which were recognized as natural, historical, cultural and landscape heritage; urban woodland, of which 350 trees were recognized as natural heritage due to their historical, natural and scenic value; and the eight plant species declared as emblematic of the city for their historical-cultural value[6].

Moreover, medicinal plants and herbs are still collected from ravines and green urban areas for domestic use. This kind of healing is deeply rooted in the city and has been practiced for several generations. The supply of seeds, leaves and roots for healing is extensive and caters to those who see traditional medicine as a natural alternative to conventional medicines.

6 Resolutions: Mountain streams / ravines No. 350 June 2012, plants No. 238 April 9th 2012, No. 784 December 23rd 2013 incorporates the Maywa (orchid) of Quito.

Environmental criteria in public spaces

Below, the environmental technical strategies that encourage the use of public spaces and help mitigate major problems such as risks and climate change are presented:

Climate regulators

Quito does not have an extreme climate and, therefore, bioclimatic conditioning actions or strategies for public spaces and buildings need not have a high degree of sophistication, especially for outdoor interventions.

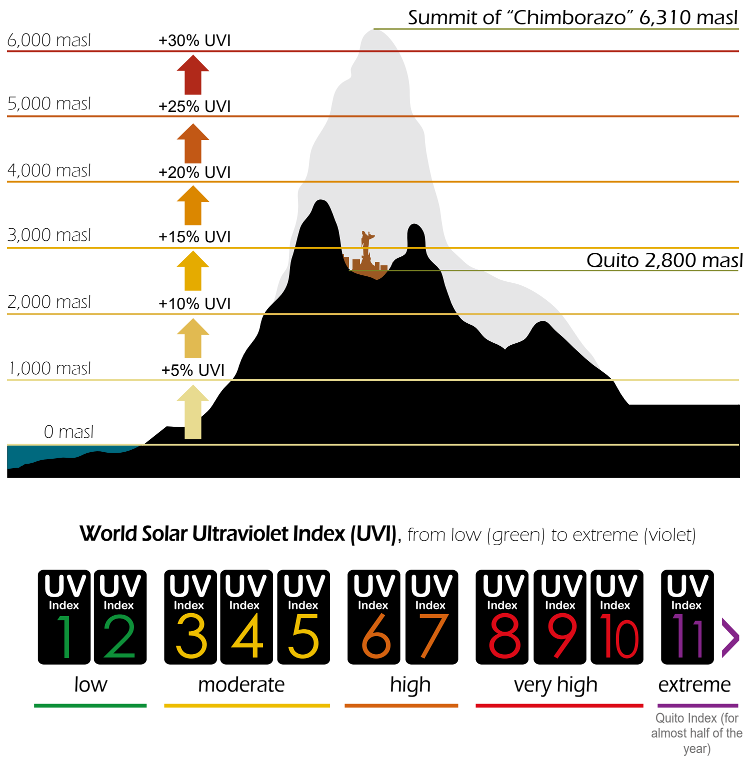
However, solar radiation, particularly in Quito, is the factor with the greatest influence on people's health, wellbeing and thermal comfort. Although during the day the city doesn't experience high temperatures, the effect of solar radiation causes people's thermal sensation to feel greater than it actually is.

According to the World Health Organization, the intensity of solar radiation depends on the following factors:

- **Altitude:** The intensity of UV radiation increases 5% for each 1,000 meters of altitude.
- **Sun elevation:** The higher the sun is in the sky, the greater the intensity of ultraviolet radiation.
- **Latitude:** The closer the location of the equator, the higher the intensity of ultraviolet radiation.
- **Cloud protection:** Ultraviolet radiation is more intense when the sky is clear, but it can also be intense even if the sky is cloudy.
- **Ozone Layer:** Ozone gas absorbs some of the ultraviolet radiation from the sun. As the ozone layer thins, the amount of ultraviolet radiation reaching the Earth's surface increases.
- **Surface reflection:** Many surfaces reflect sunlight and increase overall exposure to ultraviolet radiation.

Quito is the thirteenth highest city in the world with more than 1,000,000 inhabitants, and within this list it is the only city located at **Latitude** 0°. Quito's conditions make it one of the cities with the highest intensity of solar radiation in the world (*Infographic 9*).

A study by the Secretary of the Environment, in the period 2009 to 2011, shows that in the city of Quito the ultraviolet index (UVI) is greater than or



Infographic 9. Increase in the intensity of ultraviolet radiation with altitude
Source: STHH Secretary of Territory, Habitat and Housing Urban Development Metropolitan District UDMD

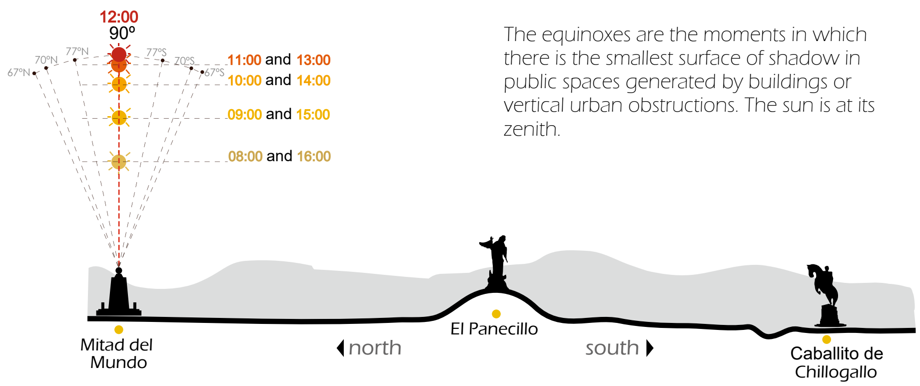
equal to 11 for nearly half the year (45.20% of the year, 11 is considered to be extreme by the WHO). This means that for almost half of the year the city's population is exposed to extreme levels of UV radiation (*Infographic 10*).

Frequent or prolonged exposure to solar radiation causes health disorders, especially to the skin and eyes. For this reason the minimization of the effects of solar radiation has become the main strategy for achieving favorable microclimates in Quito, particularly in order to encourage the use of public spaces.

Furthermore, alterations to the temperature in the city or the 'heat island' effect are generally speaking a product of solar radiation and air pollution. In the case of Quito, peak heat occurs during the five hours of maximum exposure to solar radiation.

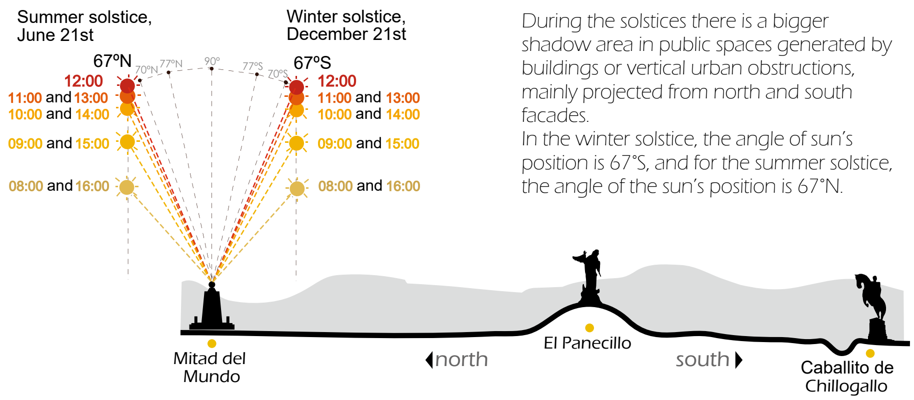
Infographic 10. Sun elevation in Quito. (Latitude 0)

EQUINOXES: March 21st and September 21st

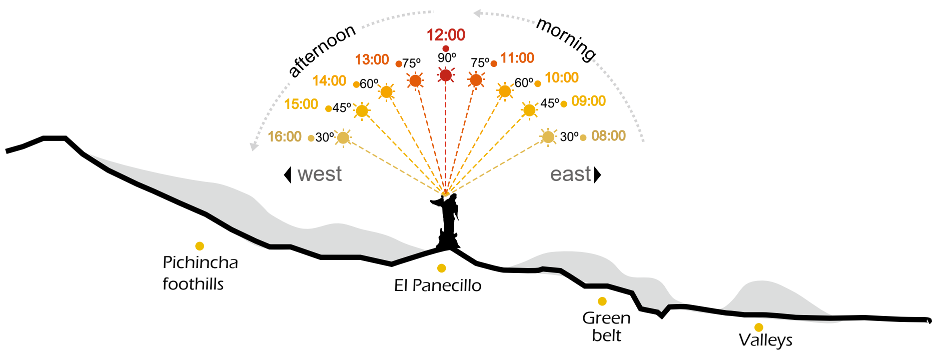


Sun Elevation in Quito (Latitude 0)

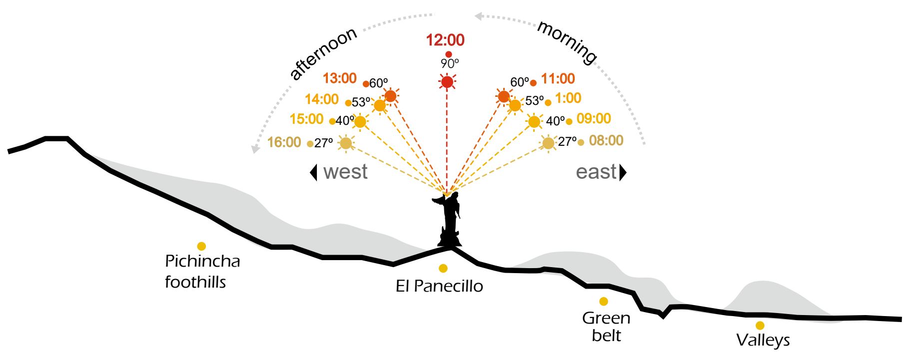
SOLSTICES



EQUINOXES: March 21st and September 21st



SOLSTICES: WINTER, December 21st / SUMMER June 21st



Source: STHH - UDMD

To understand more on this subject, solar radiation is emitted in the form of electromagnetic waves which by themselves do not heat the space they traverse; however, the opposite effect is caused when electromagnetic waves pass through spaces with little clarity such as pollution, humidity or dust, the result being that radiation heats these spaces. As such, temperatures are higher in an average urban microclimate (1 to 4 degrees higher) than in the surrounding environment or rural areas, as a result of air pollution.

The behavior of radiation to any obstacle can be manifested in three physical phenomena (*Infographic 11a*).

Thus, all elements of the external environment and public spaces affected by solar radiation shall be subject to these phenomena, causing favorable or unfavorable secondary effects.

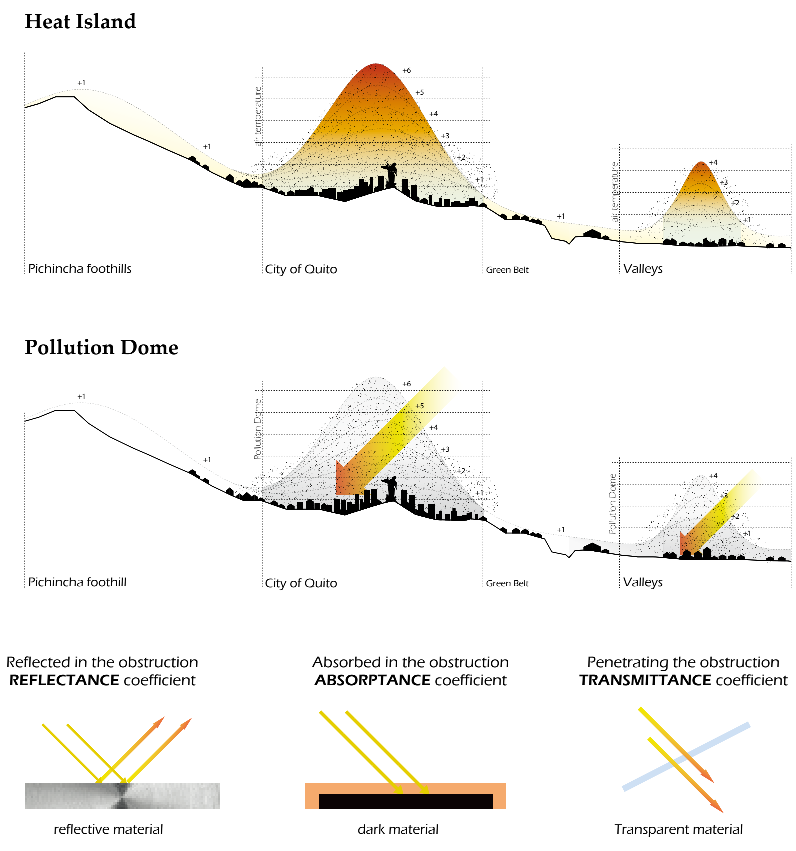
We receive solar radiation in several ways:

- Directly from the sun, in its direct, diffuse or reflected forms.

- Indirectly, through bodies heated by solar radiation, which once absorbed heats nearby air by means of convection.

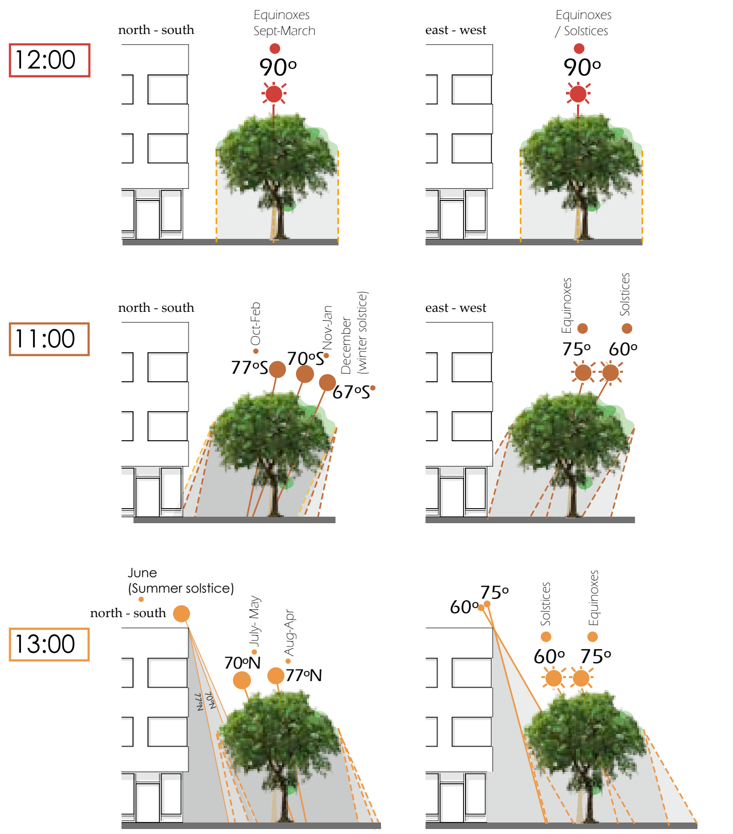
Vegetation and water bodies are surfaces that have low reflection and heating when exposed to solar radiation; in both, part of the absorbed energy is used for the evaporation of water (Neila, 2004) (*Infographic 11b*).

Urban trees and vegetation are alternatives for the minimization of the effects of solar radiation, for both 'thermal comfort' and for reducing the 'heat island'



Source: STHH - UDMD

Infographic 11a. The behavior of radiation



Source: STHH - UDMD, 2016

Infographic 11b

effect, by generating shading and increasing vegetation surfaces in general.

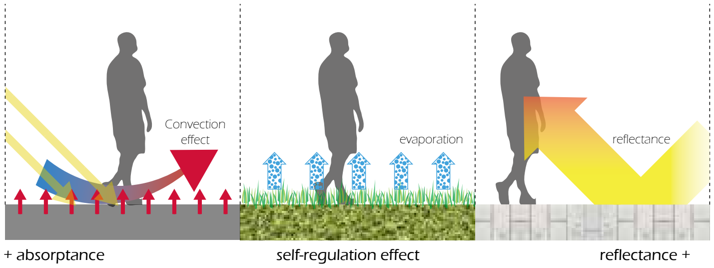
To create shade, the strategy is to provide the city with urban trees; this, along with other urban elements such as buildings, helps prevent exposure to solar radiation in public spaces, especially during the five hours of greatest intensity (10:30am to 3:30pm), as in this period 80% of daily UVI is received.

An increase in vegetation surfaces is important to Quito, as despite having a high coefficient of absorptance these surfaces do not heat the air temperature; on the contrary, they self-regulate through the process of evapotranspiration (*Infographic 12*).

It is true that there are many sustainability texts and certifications that recommend, support and encourage the use of highly reflective materials as a fundamental strategy for minimizing the 'heat island' effect. However, this is not recommended in the case of Quito, since, as noted above, the intensity of solar radiation is extreme for almost half of the year, and reflections from surfaces increase the exposure of the pedestrian to radiation in public spaces, and therefore disruptions to the health, wellbeing and the thermal sensation of the population also increase.

In addition to vegetation, to prevent radiation reflecting from hard floors in public spaces (such as surfaces on sidewalks, roads and plazas), colors should be intermediate, not too dark (absorptance) or very clear (reflectance) (*Table 4*).

And finally, one of the actions for reducing pollution in cities is to generate favorable microclimates to encourage the use of public spaces and non-motorized mobility.



Infographic 12. Absorptance and reflectance
Source: STHH - UDMD, 2016

Table 4. Behavior of materials with solar radiation

FINISH	ABSORPTANCE coefficient	REFLECTANCE coefficient
Silver or polished aluminum	0.02	0.98
Plaster	0.08	0.92
Matt white paint	0.10...0.25	0.90...0.75
Polished aluminum	0.10	0.90
Matt silver	0.12	0.88
White brick	0.15	0.85
Mirror	0.15	0.85
Galvanized steel	0.25	0.75
Glass	0.30	0.70
Light-colored paints	0.30...0.40	0.70...0.60
White marble	0.37	0.63
Medium-colored paints	0.50...0.70	0.50...0.30
Stainless steel	0.45	0.55
Vegetation	OPTIMUM: The absorbed energy is used for water evaporation	
Light-colored cement	0.55	0.45
Concrete	0.60...0.70	0.40...0.30
Yellow brick	0.67	0.33
Red brick	0.77	0.23
Dark cement	0.78	0.22
Dark-colored paints	0.80...0.90	0.20...0.10
Tar	0.85	0.15
Granite	0.87	0.13
Wood	0.90	0.10
Asphalt	0.95	0.05
Brown brick	0.97	0.03

INTERMEDIATE COEFFICIENTS

Source: STHH - UDMD, 2016

Natural barriers: prevailing winds and pollution

Vegetation acts as a natural barrier against prevailing winds, at times when the lowest temperatures are recorded, and in cases where there is noise pollution, especially in areas with heavy traffic.

In the case of Quito, natural barriers against prevailing winds in public spaces should be placed based on the average time when lower temperatures are recorded during the year (17:30pm to 8:30am), i.e. in the late afternoon, through the night to the early morning.

To do this, the direction of prevailing winds and their velocity should be evaluated by area in order to strategically place the natural barrier in the public space, taking into account that winds in excess of 10 m/s begin to generate discomfort for the pedestrian. The Beaufort scale is used as a reference with respect to wind velocity (*Infographic 13*).

Generally, it is known that air movements in cities tend to be more turbulent than in the countryside where vegetation, maintaining a flexible stance against wind, prevents undesirable pressures that usually cause increased air speed (*Infographic 14*).

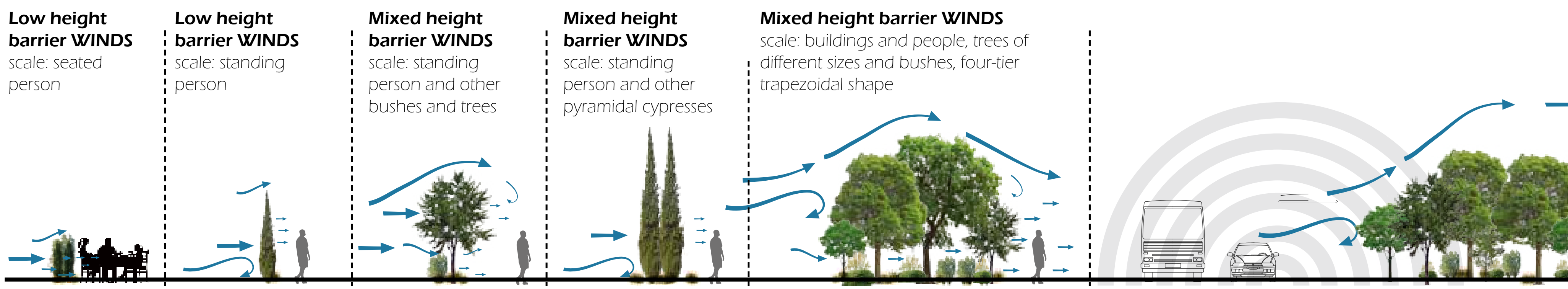
Moreover, in the city there are many activities generating noise or acoustic pollution, which has implications for the health and tranquility of citizens. This pollution is mainly generated by vehicles. Pollution increases proportionally to the intensity of traffic.

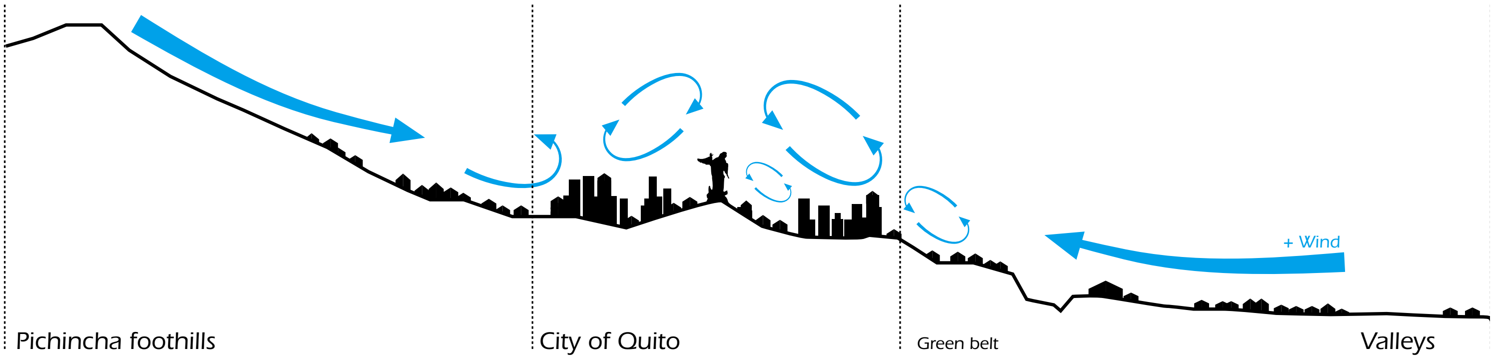
The effects of noise on human beings can be physiological, such as hearing loss and negative effects on blood pressure and circulation, or psychological, such as excessive irritability, although these are usually related. The use of vegetation as noise protection requires sufficiently dense forests for the direct mitigating effect to be appreciable. Even greater is the indirect effect, when the cause of the discomfort cannot be seen, thus diminishing psychological harm. Another experimentally verified psychological effect vegetation has on human beings is known as the Ulrich effect (1975), or the reduction of stress (Vegetation Guide for Urban Environments, 2005).

Effect	Velocity (meters/second)	Reference description	Effect	Velocity (meters/second)	Reference description
	0.0 - 0.2 m/s	Smoke ascends vertically		10.8 - 13.8 m/s	Umbrella use becomes difficult
	0.3 - 1.5 m/s	Smoke changes direction		13.9 - 17.1 m/s	Trees sway
	1.6 - 3.3 m/s	Leaves move		17.2 - 20.7 m/s	Twigs break off
	3.4 - 5.4 m/s	Small branches move		20.8 - 24.4 m/s	Slates blow off roofs
	5.5 - 7.9 m/s	Loose papers fly		24.5 - 28.4 m/s	Trees uproot
	8.0 - 10.7 m/s	Small trees sway		above 28.5 m/s	Damage intensifies

Infographic 13. BEAUFORT scale

Source: STHH - UDMD, 2016





Infographic 14. Wind circulation

Source: STHH - UDMD, 2016

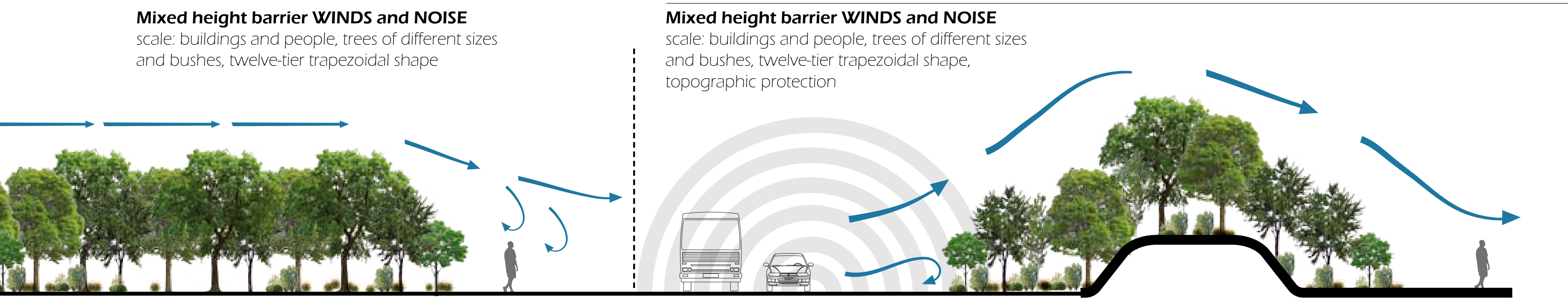
The intensity of sound is measured with an instrument called a decibel meter and the unit of measurement is the decibel (dB). In general, the maximum intensity of sound recommended by the World Health Organization is 65 dB during the day and 55 dB at night, measurements higher than this figure being considered noise or acoustic pollution. As a reference, *Table 5* presents the decibel scale according to the source of noise.

In order for vegetation to function effectively as a natural barrier against prevailing winds and noise pollution, the following aspects should be taken into account (*Infographic 15*).

Table 5. Source of noise and their intensity in decibels.

Source	dB
Human whisper	10
Quiet rural area	20
Quiet suburban area (nighttime)	30
Quiet urban area (nighttime)	40
Quiet urban area (daytime)	50
Normal conversation	60
Busy office	70
Scream (at a distance of 1 meter)	80
Diesel truck at a distance of 15 meters	90
Pneumatic drill	100
Riveting machine	110
Airplane take-off	120
Pain threshold	130

Infographic 15. Protection provided by vegetation against prevailing winds and noise pollution



Permeability

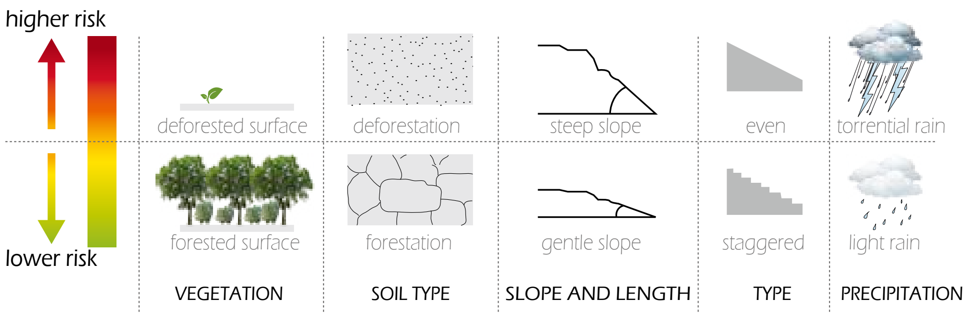
Soil permeability refers to the capacity for water infiltration. Permeability responds to the following relationship: higher soil permeability means increased water infiltration, and increased impermeability means increased water runoff.

Soil permeability corresponds to the vegetated surface; in the case of cities, there is an alteration of natural cycles due to soil sealing, i.e. the replacement of a vegetated surface with an asphalt surface. Soil sealing disrupts the natural water cycle, and results in the impossibility of replenishing underground aquifers, increased water runoff causing flooding, an increase in the 'heat island' effect, and landslides (*Infographic 16*).

The MDQ is a highly vulnerable territory to natural and man-made disasters. The most recurrent events, since 1970 in the urban center of the district, have been those events linked to hydromorphological phenomena, i.e. torrential rains, floods, mudflows and landslides.

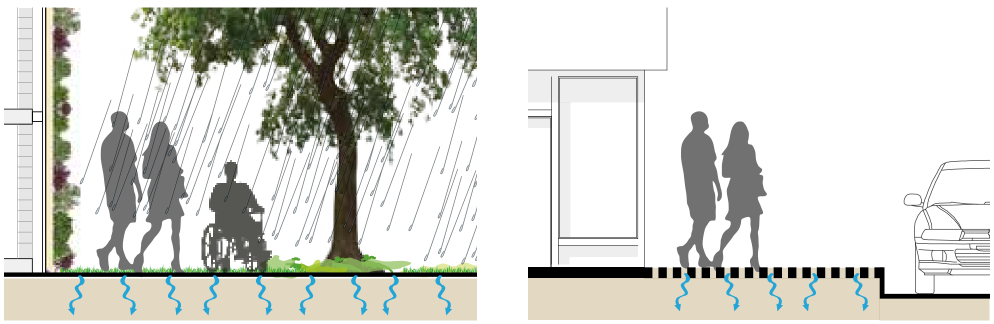
Soil sealing in cities increases flood irrigation, and sewerage networks often flood when there is a higher percentage of rainwater runoff. The optimum process is to increase the surface of permeable vegetation in the city for its multiple benefits; however, this can be combined with the use of porous hard material that allows water infiltration (*Infographic 17*).

Conversely, forest areas of large trees have a 'brake' effect on rain on hillsides, which does not occur in totally unprotected agricultural land. This forest surface reduces the risk of soil erosion and therefore reduces the risk of landslides. It should be clarified that deforestation is not the only cause of soil erosion, which also depends on the soil type (shallow and sandy soils are the most erodible), the slope (steeper slopes have increased risk), and length (longer slopes with more inclination are more erodible). Two or more of these soil eroding



Infographic 16. Factors that increase the risk of landslides

Source: STHH - UDMD, 2016



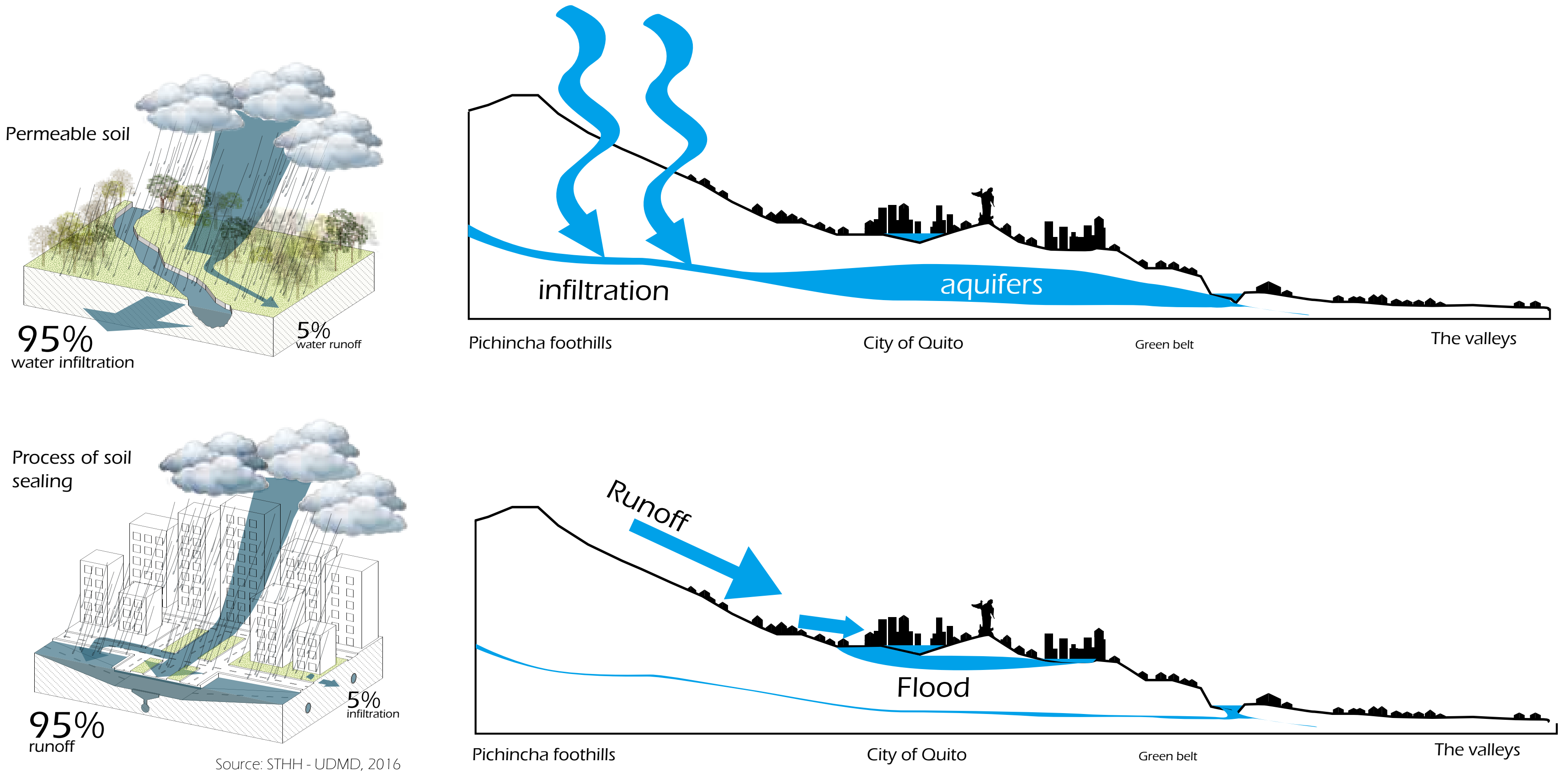
Infographic 17. Surfaces of permeable vegetation in the city

factors, combined with a high level of precipitation, cause landslides. The implementation of plant barriers or agricultural practices like terrace farming can reduce this risk (The City and the Natural Environment, 2007).

In the case of Quito, deforestation on slopes would mean that the soil becomes compact and loses the porous characteristics that the roots of trees, shrubs or foliage provide, which would mean an increase in the volume of runoff water.

This would represent a problem for the consolidated city in the rainy season (from October to May, 8 months), as in addition to the flooding caused by the high percentage of soil sealing in the city, an additional volume of rainwater runoff would come from the slopes in the event that these were without vegetation.

The "mountain highlands" in the country represent the point of water origin; the City of Quito is located on the slopes of one of the points of origin of the water cycle. As such, the water quality of other populations in the country depends on the management of water resources in Quito, the capital city. For this reason, the replenishing of underground aquifers and the prevention of their contamination are important (*Infographic 18*).



Infographic 18. The City and the Natural Environment

Source: STHH - UDMD, 2016

Citizen participation in the implementation of Environmental Good Practices

Promoting a culture of Environmental Good Practice (EGP) is critical to building a sustainable city and requires the joint efforts of the Municipality and the general public: neighborhoods, educational institutions, businesses and civil society organizations.

To this end, the Secretary of the Environment has defined guidelines and strategies for the implementation of EGP, which constitute a set of simple actions involving a change of attitude and behavior of people in order to achieve a friendlier relationship with the environment.

One of these strategies is the EGP Program for different sectors of the population, which contains a practical methodology serving as a guide so that different sectors of the MDQ can actively participate in reducing carbon, water and ecological footprints.

The stages of the EGP Program are:

Environmental team training

The first step is the creation of the institution or neighborhood's environmental team. This team will lead the implementation of all subsequent stages of the EGP Program and is responsible for motivating all members of their institution or their neighbors to participate actively in the development of activities.

Resource consumption diagnostics

After forming the environmental team, the next step is to perform resource consumption diagnostics. These diagnostics permit knowledge of the current situation and identification of the main needs in relation to the environmental performance of the institution or neighborhood.

The main activities performed in the diagnostics stage are:

- Waste characterization
- Surveys to assess environmental performance

Photo: Pamela García

Reforestation of the Pichincha mountainside.

- Records of the consumption of water, energy and supplies
- Tours to identify critical points

Design and implementation of measures to reduce footprints

Based on the diagnostics, the environmental team defines a series of preventive and corrective measures and actions to reduce the footprints of the institution or neighborhood. The axes to classify these measures and actions are:

- Water
- Energy
- Waste
- Mobility
- Natural heritage

Communication and monitoring plan

To ensure project sustainability, encourage participation and sensitize all members of the institution or neighborhood, it is essential to define a cross-cutting communication and monitoring plan. This plan includes internal and external awareness campaigns and defines who is responsible for ensuring that the planned measures and actions are adequately implemented (*Infographic 19*).

Metropolitan Environmental Distinction: Sustainable Quito (MED SQ)

The Metropolitan Environmental Distinction: Sustainable Quito (MED SQ) is a public recognition given every year by the Secretary of the Environment to individuals, neighborhoods, businesses and institutions that implement Environmental Good Practices (GAPs) to reduce their footprints.

The categories of people who can participate in the MED SQ are:

- Natural persons
- Micro, Small, Medium and Large Enterprises
- Neighborhoods, Housing estates and Gated communities
- Universities and Educational Institutions
- Civil society organizations
- Public institutions

The MED SQ consists of evaluating a series of qualitative indicators classified in the following categories:

- Sustainable mobility
- Environmental Good Practices to reduce footprints
- Care for natural heritage
- Adequate waste management
- Sustainable construction

The participants in each category who receive a higher rating than the percentages defined in the baselines of the MED SQ can attain one or more honorable mentions or the Environmental Distinction according to their performance in all the categories.

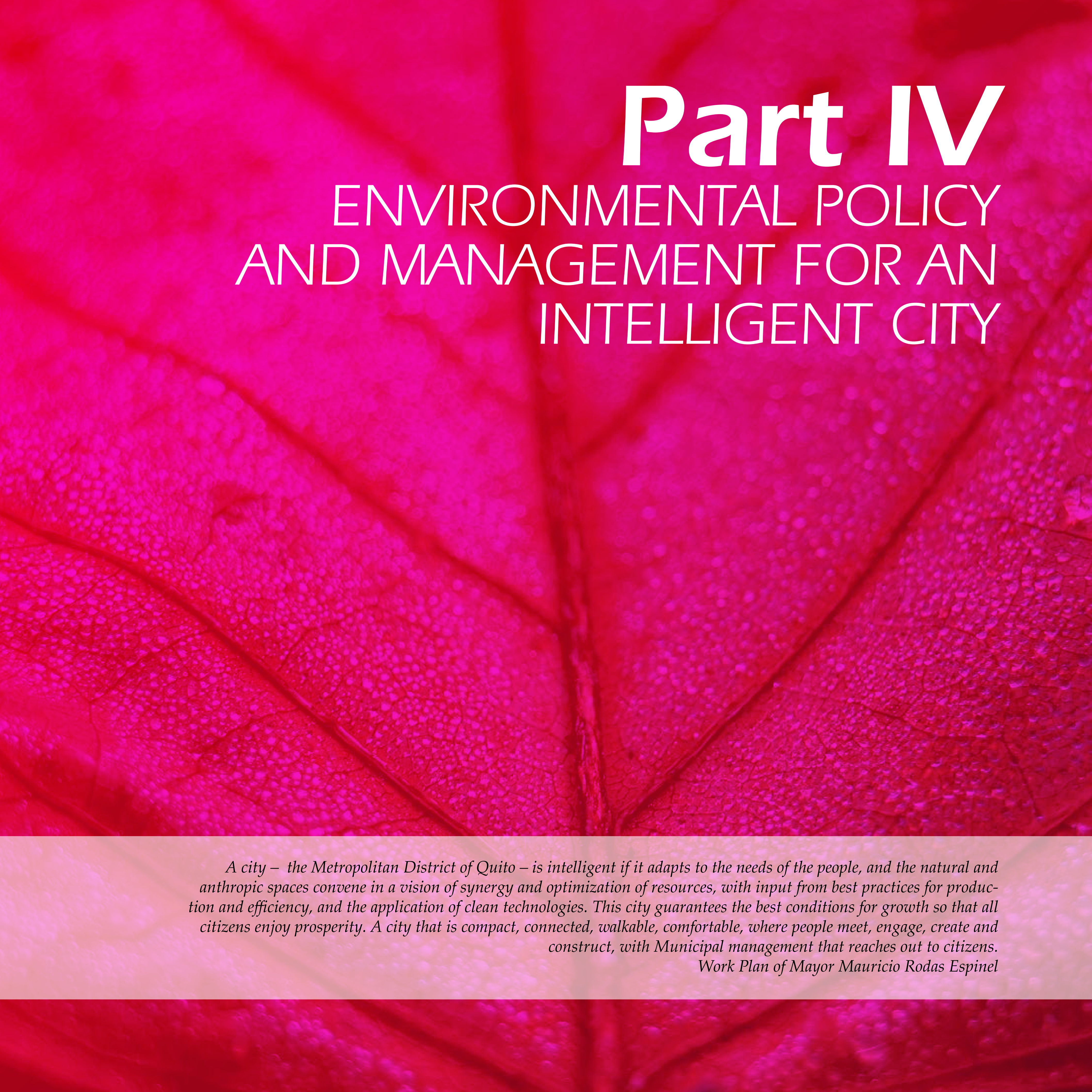
The MED SQ allows citizens to assess their environmental performance and know what actions can be implemented to improve their relationship with the environment, and also highlights the various actions for implementation which represent a model for all the inhabitants of the MDQ to follow. Importantly, the award recognizes the will of all those who participate and on a year to year basis evaluates progress in their performance towards achieving a level of accomplishment.

Infographic 19. Environmental Good Practice

Source: Secretary of the Environment, Department of Environmental Good Practice, 2015

• People • Households • Micro, Small, Medium and Large Enterprises • Neighborhoods, Housing Estates, Gated Communities, Communes • Universities and Educational Institutions • Civil Society Organizations • Public Institutions

First Environmental Distinction Award, Metropolitan Secretary of the Environment, 2015.



Part IV
ENVIRONMENTAL POLICY AND MANAGEMENT FOR AN INTELLIGENT CITY

A city – the Metropolitan District of Quito – is intelligent if it adapts to the needs of the people, and the natural and anthropic spaces convene in a vision of synergy and optimization of resources, with input from best practices for production and efficiency, and the application of clean technologies. This city guarantees the best conditions for growth so that all citizens enjoy prosperity. A city that is compact, connected, walkable, comfortable, where people meet, engage, create and construct, with Municipal management that reaches out to citizens.
Work Plan of Mayor Mauricio Rodas Espinel

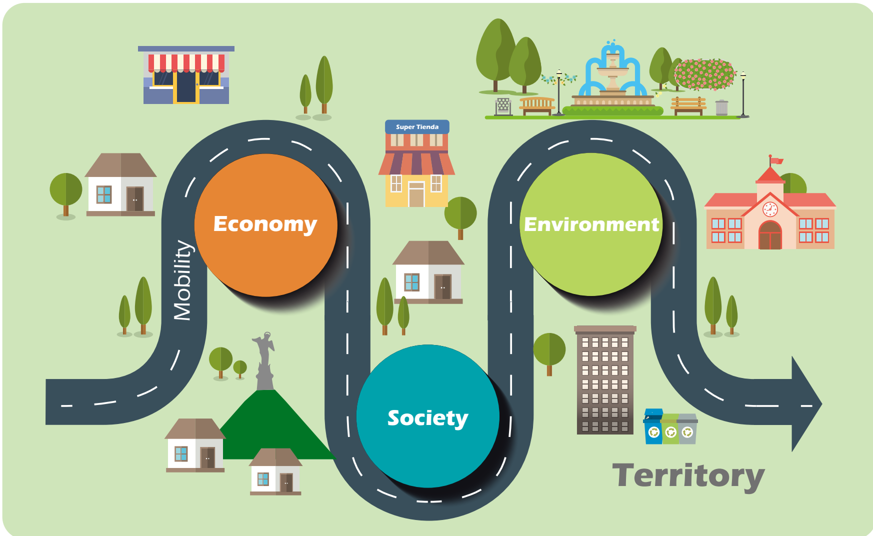
Panoramic view of Quito

Photo: Anaís Córdova-Páez

KEY AXES GOVERNING CITY DEVELOPMENT

Quito, in the framework of the comprehensive vision of the Metropolitan Development and Territorial Management Plan (MDTMP) 2015 to 2025, has established territorial strategic guidelines with a holistic focus to determine the form of territorial organization required in order to achieve a sustainable city from the triple perspective of the *environment, the economy and society*. This new conceptual vision, 'Quito: sustainable city', is constructed through policies – both for the municipal sector and for the citizenship – which prioritize prevention rather than punishment, promote a culture of environmental good practice and generate active participation from all sectors of society. The collective work of the municipality with companies, academia, civil society organizations, citizens and government institutions will enable us to reduce our footprint on nature, respond to the effects of climate change, and create a city in which we can live better (*Infographic 1*).

The Metropolitan Development and Territorial Management Plan 2015-2025 (MDTMP) establishes three strategic areas: a smart city, a city of opportunities and an inclusive city.



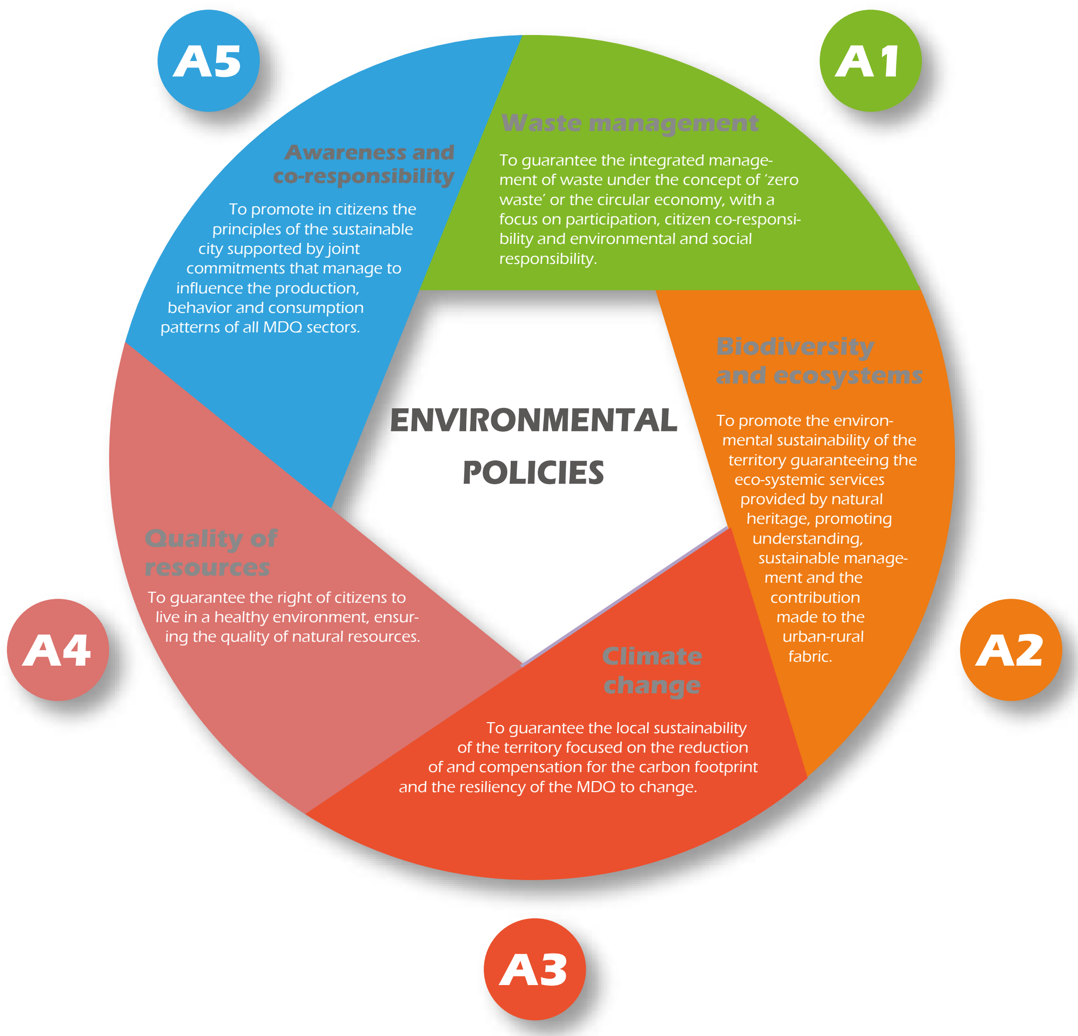
Infographic 1. Interactivity in the municipality

The axis 'Quito: solidary city' contains the fields of social development and those related to human development: education, health, culture, social inclusion, security, citizen participation and governance.

The axis 'Quito: a city of opportunities' contains the fields related to economic development, which promote activities that foment productive development, competitiveness, the solidary economy and endogenous development, among others.

The axis 'Quito: intelligent city' covers three aspects: 1) environmental development, proposing how to achieve alignment between environmental conditions and the needs of the people, 2) territorial planning, in reference to ordering the territory so that the development processes performed are carried out in the best conditions, and 3) mobility, concerning how people and goods move and connect to invigorate and provide efficiency to these processes.

For each of the axes, policies, objectives, goals and strategic lines have been established, as displayed in *Infographic 2*.



Infographic 2. Integration of the five policies found in the 2015-16 District Environmental Plan

Waste management policy

> To guarantee the integrated management of waste under the concept of 'zero waste' or the circular economy, with a focus on participation, citizen co-responsibility and environmental and social responsibility.

Solid waste represents a continuing problem of environmental pollution facing any city with inadequate handling of waste. This causes problems for public health and is an infectious focus for the proliferation of vectors and diseases. These problems can be identified throughout the lifecycle of each product, from their origin to their final disposal.

The city's hygiene and the awareness of its citizens in terms of prevention of environmental pollution by waste is the responsibility of the municipality. These activities require strengthening processes for communication, participation and citizenship co-responsibility that become increasingly personalized and direct in order to improve effectiveness and efficiency in the processes of collecting, sorting, final disposal and utilization.

Participation and co-responsibility seek to create an awareness of consumption activities that allows a reduction of the waste generation at source; while industrial co-responsibility must respond to this kind of responsible consumption and reorient productive activities based on so-called 'ecodesigns', which require less raw material and more recycled material.

Citizen participation in the process of co-responsibility requires shared commitments and obligations from both the public and the private sectors.

The Municipal Metropolitan District of Quito (MMDQ) has established an intervention strategy to ensure integrated solid waste management under the concept of 'zero waste', also known as the circular economy, containing a focus of participation, co-responsibility and environmental responsibility.

The 'zero waste' concept comprises of the strategic lines displayed in *Figure 1*.

Advertising publications from the waste sector

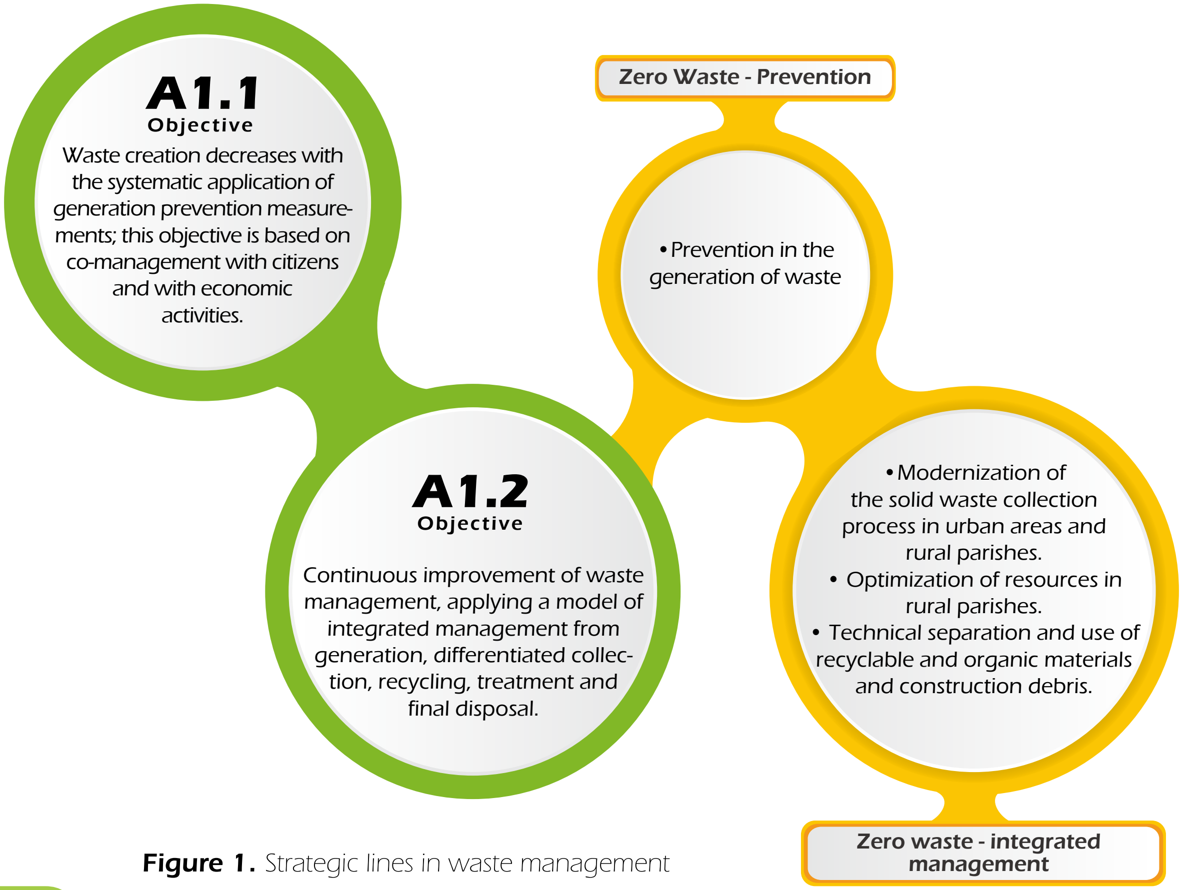


Figure 1. Strategic lines in waste management

Developed countries address the problem of waste management under the following lines of action:

1. Conservation of raw materials, preventing waste.
2. Improvement in the efficiency and substitution of materials in production.
3. Changes in consumption behavior.

This concept seeks to strengthen the processes involved in the value chain of waste management, improving service quality and reducing the environmental impact on soil and water, as well as the emissions of greenhouse gases generated.

These processes begin with the application of preventive measures based on co-management and co-responsibility with the citizenship and with public, private, national and international productive agents.

Integrated waste management

The world has more than seven billion people who are consumers and, therefore, generate waste that contaminates soil, water and the air and alters the functions of the ecosystem and the landscape.

In this context, the MDQ is no stranger to the trend of consumption and pollution; today, waste is a crucial element for the management of natural resources, because the world's consumption of increasingly scarce fossil fuels and raw materials is growing.

The Secretary of the Environment positions waste management as a circular economy process and considers it very important in terms of impacting upon the quality of life of citizens and contributing

Infographic 3. Stages in waste management towards a circular economy.
Five phases on the path from waste management to waste as a resource (Source: Steps to modern Waste Management – Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety)

to local and national economic growth, minimizing impacts and improving social and environmental conditions.

There are five stages of waste management towards the development of a circular economy (*Infographic 3*).

Stage 1: Uncontrolled dumping / tipping

Uncontrolled dumps in the MDQ have declined in activity since August 1969, with the creation of the controlled 'Boca del Lobo' dump. As shown in *Article 1* by Figueroa and Lara, waste management in the district was not optimal, and there was no utilization during the value chain of production, collection and final disposal. Management had the concept of 'waste'. Uncontrolled dumps are open air without any treatment or control.

Article 1. FIGUEROA, Oswaldo
REFBIB.:021

Until 1969, all solid waste produced in the city was dumped in the Machángara River, in the sector known as 'Censo'. In August of that year the first controlled dumping site was created, in the 'Boca del Lobo' ravine in the south sector. From that point, the 'era of controlled dumping' began.

Oriental forest (pp.3)

DESCRIPTORS: SANITATION, SOLID WASTE
TEMPORAL SCOPE: 1969

Stage 2: Optimized collection and controlled landfill

In 1994 operations for the adequate collection, sweeping and transportation of waste began. The replacement of dumps with a landfill site (Zámbiza) generated a rationalization in the management, control and regulation of waste and gave the activity of waste management an economically cost-effective and efficient character.

Currently, systematic waste collection is performed by EMASEO-EP, and disposal of controlled waste is managed by EMGIRS-EP in the El Inga landfill site, continuing to this day the linear condition of waste management (*Figure 2*).

In the MDQ there are 54 edible product markets producing around 80 tons of daily waste, of which approximately 85% is organic collected waste whose final destiny is the El Inga landfill site, where it is disposed without any treatment or use.

Stage 3: System of recycling and composting

In 1993, the MDQ began recycling and composting processes; however, this initiative did not prosper and was limited due to changes in the collection schedule and the city's growth. This stage includes the development of production projects for selective collection and recycling, and for organic and other materials.

Currently, the MMDQ has begun the construction of separation plants with mechanized technical processes for the classification of organic and inorganic material, including recyclable waste (paper, cardboard, plastic, glass and metal). Also, the first composting plants for the utilization of organic material have opened. These new structures have reached stages of commercialization favoring the development of a new recycling industry, generating employment and income and the management of a circular economy in the waste sector.

The MMDQ plans to create a new differentiated collection for the 70 daily tons of organic materials generated in the markets. To achieve this, it is necessary to implement and operate a municipal composting system that ensures a stock of fertilizer and/or liquid-biological fertilizer for trade which would be sold in the same markets.

Figure 2. Linear design

Differentiated collection

Stages 4 to 5: Transition of waste disposal

Stages 4 to 5 mark the transition from waste disposal to the management of a circular economy of resources, which takes full advantage of waste as material or as energy for those non-recoverable materials. Common recyclable and waste products are selectively collected in modern treatment facilities for the separation and utilization of waste.

In the future, integrated waste management will be an integrated circular system. That means a circular economy with the inclusion of the different types of waste produced in the MDQ, which will achieve efficiency throughout the value chain (*Figures 3 and 4*), from a reduction in waste generation, to collection and economically efficient transport, the classification and effective recovery of all types of waste, reuse, treatment and utilization of materials, and utilization for energy, without any risk to the environment and minimizing emissions of greenhouse gases (GHG) for the effective management of waste produced in the MDQ.

The current goal is the development and implementation of the Master Plan for Waste Management, based on the concept of the 'circular economy'.

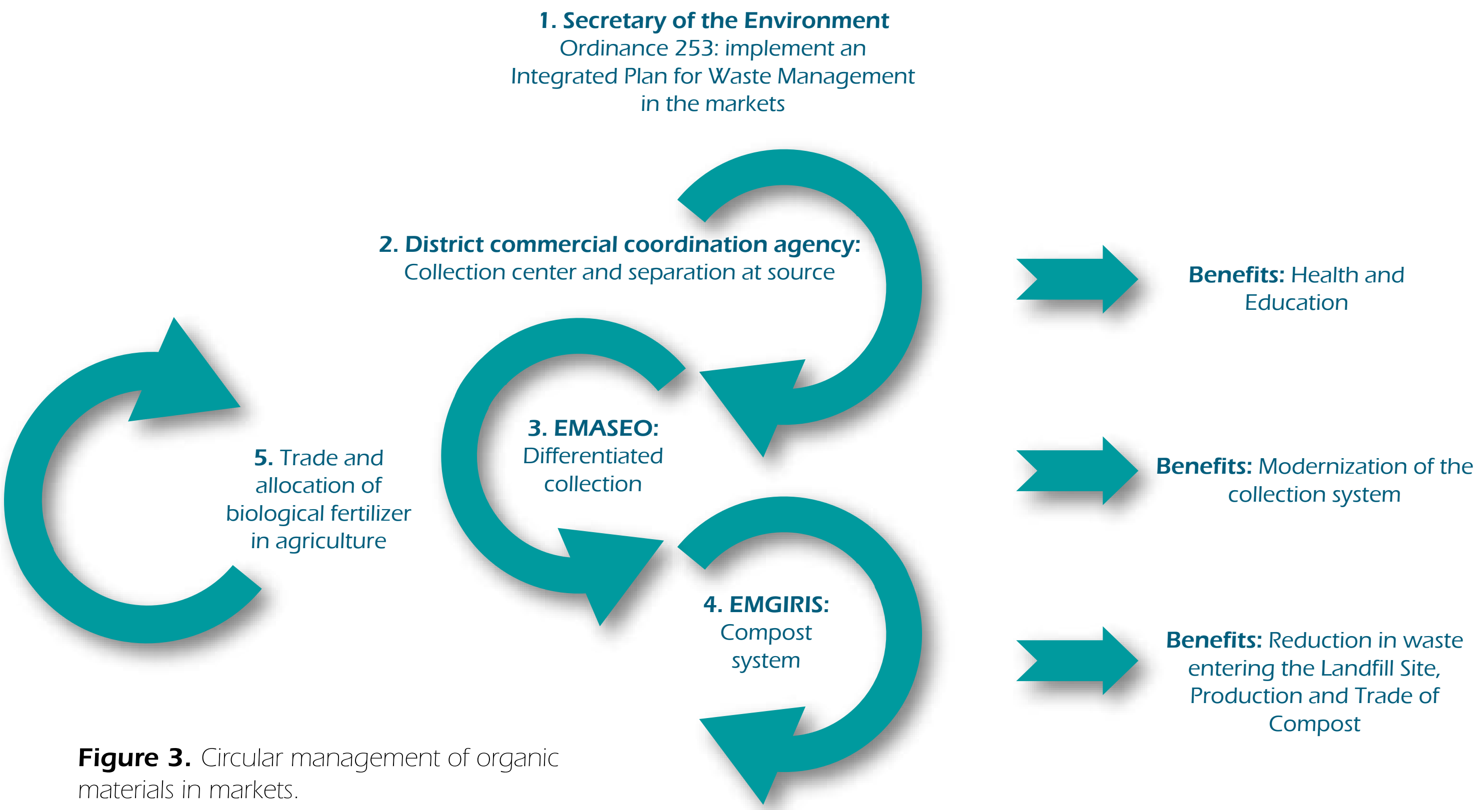


Figure 3. Circular management of organic materials in markets.

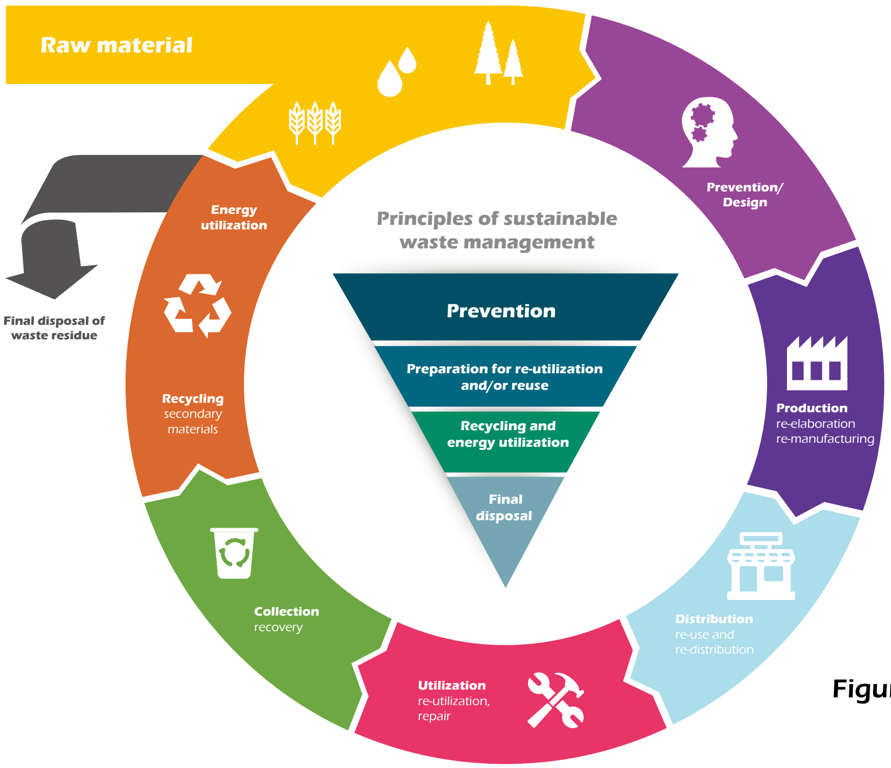


Figure 4. Circular management

Scheme of Integrated Waste Management in the MDQ

The Integrated Waste Management scheme (*Infographic 4*) was developed from two axes of intervention:

Separation of waste, under a public-private participatory scheme with co-responsibility shared between Municipal and industrial managers, establishing mechanisms for prevention, precaution and control:

- Separation in the North and South Transfer Stations.
- Source separation. Citizens are part of an integrated circular management.
- Separation and management of special waste, hospital waste and debris.
- Decentralized systems for parishes.

Waste value chain, under a public-private scheme for waste management:

- Waste generation.
- Collection and transportation.
- Treatment and classification of waste.
- Utilization depending on the type of waste.
- Final deposit.
- Financial sustainability through the commercialization of materials.

Non-hazardous domestic and industrial waste

North and South Transfer Station (TS)

Inhabitants of Quito each produce 0.85 kg of waste per day

The main collection is divided into two types: Mechanized Collection (current 40% - forecast 81% of the population of the MDQ) and non-mechanized curbside collection (current 60% - forecast 19% of the population of the MDQ).

Currently, EMASEO-EP collects around 1,800 tons of non-hazardous household waste daily and transports it to the transfer stations (North-TS and South-TS). The composition of this waste is described in the second part of this book and constitutes approximately 24% recycled material, 57% organic material and 19% rejected material.

In the transfer stations waste is accumulated and compacted for transport and transfer to the landfill. The South-TS receives about 40% of daily waste produced in the MDQ (about 800 tons). The North-TS receives about 60% of the waste produced (approximately 1,200 tons).

Treatment and utilization

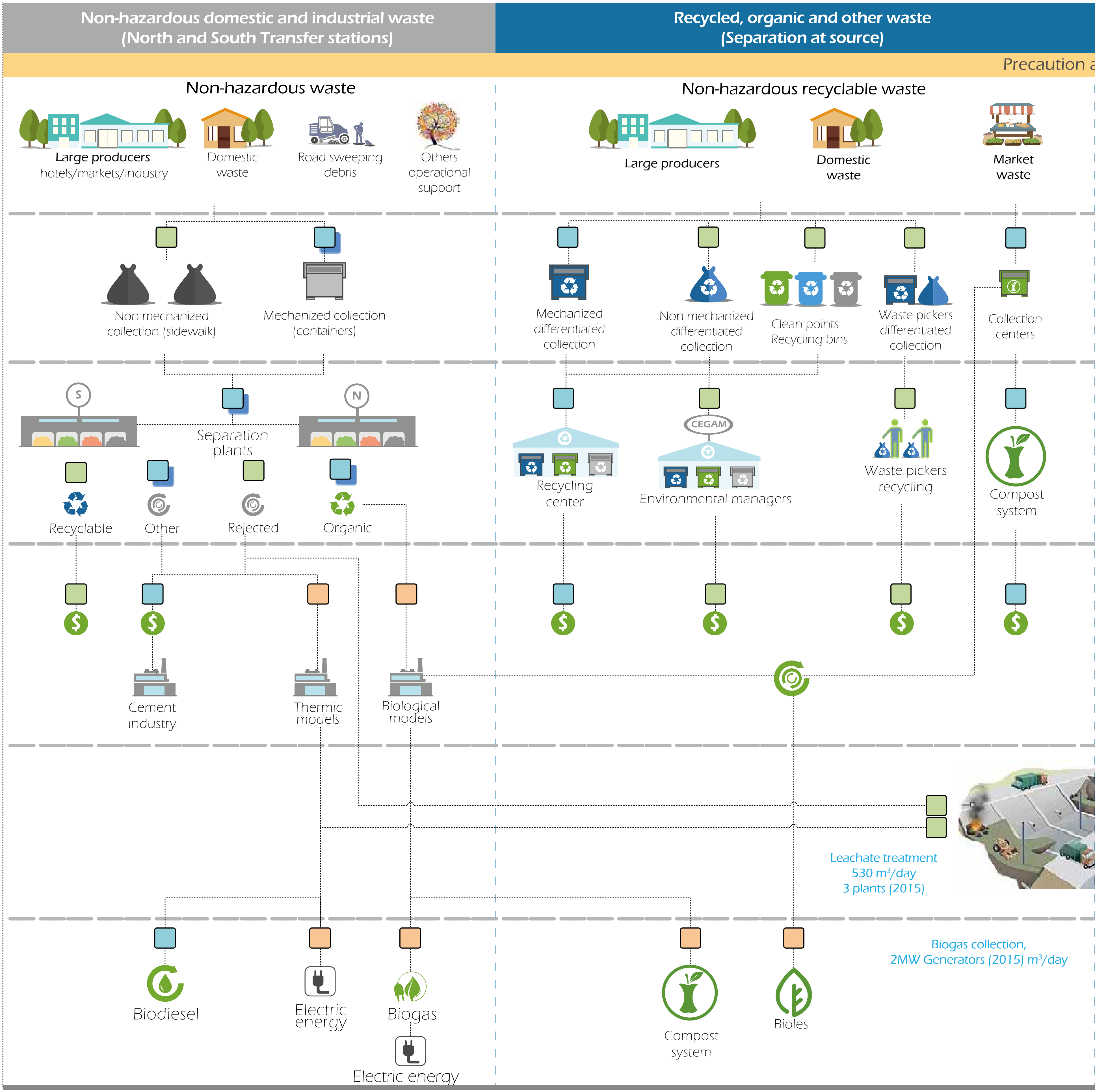
For the year 2016, the South Transfer Station (South-TS) and North-TS will become modern plants for the separation of recyclable and organic waste material. The first automated waste sorting plant in Quito will be located in the South Transfer Station and go into operation in mid-2016, being designed to treat an average of 260,000 tons/year at a rate of 30 tons/hour. It is estimated that the plant will recover between 7 and 10% of potentially recyclable material, which represents 24% of the total waste generated. Also, it will recover 57% of organic material and close to 100% of ferrous metals, representing 0.83% of the potentially recyclable material.

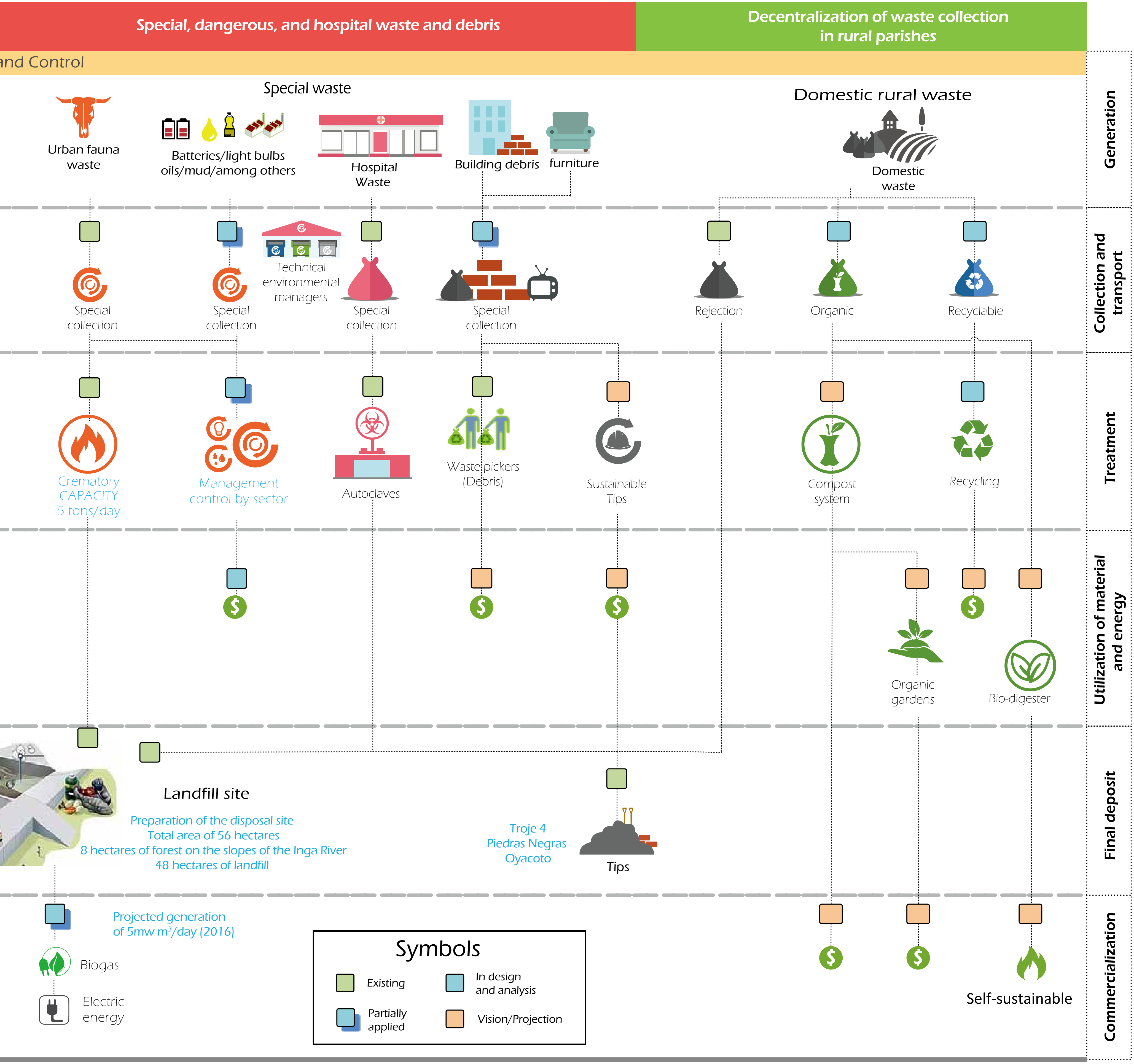
The recovered materials will be commercialized, included and reused in the economic resource cycle for the self-sufficiency of operations of the separation plants. Thus, excessive consumption of raw materials is reduced in industry.

The material not recoverable in the separation plants must be effectively exploited in the generation of new products, the commercialization of which would support the value chain.

Additional waste separated by the plants (organic and rejected material) should be exploited in possible larger-scale technologies in industries such as cement manufacture, and thermal and/or biological models

Infographic 4. Diagram of integrated waste management





Special, dangerous, and hospital waste and debris
Decentralization of waste collection in rural parishes
and Control
Special waste
Urban fauna waste
Batteries/light bulbs oils/mud/among others
Hospital Waste
Building debris
furniture
Domestic rural waste
Domestic waste
Generation
Technical environmental managers
Special collection
Special collection
Special collection
Special collection
Rejection
Organic
Recyclable
Collection and transport
Crematory CAPACITY 5 tons/day
Management control by sector
Autoclaves
Waste pickers (Debris)
Sustainable Tips
Compost system
Recycling
Treatment
Organic gardens
Bio-digester
Utilization of material and energy
Landfill site
Preparation of the disposal site
Total area of 56 hectares
8 hectares of forest on the slopes of the Inga River
48 hectares of landfill
Troje 4
Piedras Negras
Oyacoto
Tips
Final deposit
Projected generation of 5mw m³/day (2016)
Biogas
Electric energy
Symbols
Existing
In design and analysis
Partially applied
Vision/Projection
Self-sustainable
Commercialization

with end products such as electricity, biofuels, biogas, fertilizers and compost, among others.

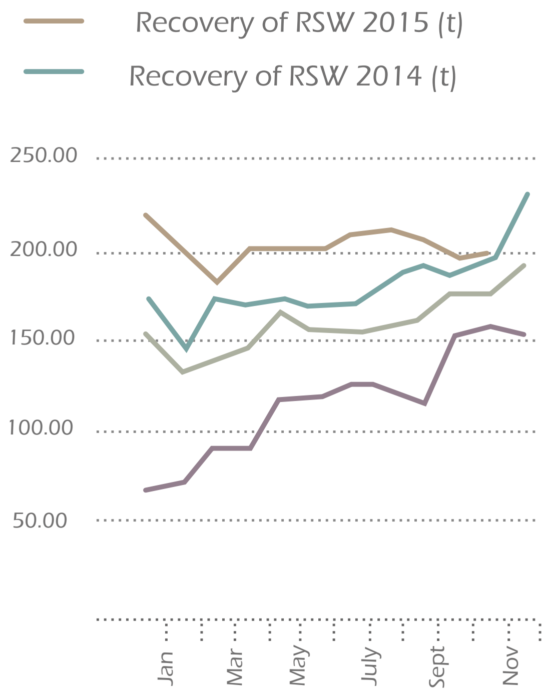
Recyclable, organic and other waste (Separation at source)

The source separation of recyclables, organic and other waste is a continuous process of co-responsibility between citizens and the separation processes of the municipal systems for differentiated collection and adequate treatment.

Currently there are 811 Green Points installed in both public and private institutions, with twelve neighborhoods benefitting from programs of non-mechanized differentiated curbside collection, the main objective of which is to involve the community in the separation of their solid waste at source, empowering small-scale environmental managers in the area to recover recyclable material in the form of curbeside collection.

Differentiated curbeside collection recovers an average of 5.05 tons of recyclable solid waste per week.

Figure 5 shows an increase of about 75% of the total recyclable solid waste recovery between the years 2013 and 2015 at the Metropolitan Centers for Environmental Education and Management (MCEEM), with facilities for collection and compacting of recyclable material implemented by the municipality as part of the Differentiated Collection with Social Inclusion Project.



Month	Recovery of RSW 2015 (t)	Recovery of RSW 2014 (t)	Recovery of RSW 2013 (t)	Recovery of RSW 2012 (t)
January	217.95	172.28	152.93	67.45
February	198.68	147.24	135.5	73.74
March	183.03	174.32	143.63	91.32
April	203.96	167.42	148.71	93.03
May	202.53	172.65	168.21	118.88
June	203.08	170.84	155.82	122.52
July	211.07	171.35	153.39	128.41
August	210.5	185.53	159.92	125.76
September	207.32	193.28	163.35	117.21
October	196.53	190.38	176.45	154.9
November	196.37	195.49	173.88	159.76
December	231.59	231.51	192.6	154.14
Total	2,462.62	2,172.28	1,924.40	1,407.10
Average	205.22	181.02	160.37	117.26

Figure 5. Recovery of recyclable solid waste

Source: EMASEO-EP (CEGAM)

The potential exists to make the differentiated collection service in the MDQ more technical, to mechanize it.

The Differentiated Collection with Social Inclusion Project developed by the Secretary of the Environment in conjunction with EMASEO-EP and EMGIRS-EP supports approximately 110 waste pickers who are in charge of recovering all recyclable waste in the four MCEEMs, where an average of 37 tons of solid waste is recycled every week. In the MCEEMs, waste pickers are responsible for providing added value to waste: by separating, classifying and compacting it. Recyclable materials include plastic, PET bottles, plastic bags, glass, cans, scrap metal, Tetra Pak, white paper, magazines, newspaper, cardboard, exercise books, and boxes. It should be noted that despite the operating costs for the maintenance of the MCEEMs being assumed by the municipality, differentiated collection is still insufficient, which is why the Master Plan for Integrated Solid Waste Management currently being designed focuses on the principles of social inclusion and equity, reuse and recycling.

Presently, recycling activity is generally carried out directly on the streets of the MDQ by waste pickers. On average there are 3,000 waste recyclers in Quito, some of them belong to some kind of association while others perform this task independently.

Moreover, special or unusual waste generated in households is not treated in the same way as recyclable waste. In this regard, the Secretary of the Environment is planning an innovative strategy of civic co-responsibility for the delivery of problematic household waste to mobile or fixed recycling centers; this waste will be collected responsibly for further treatment and final disposal. This initiative consists of providing a special service to the public, so they can leave their uncommon and problematic waste, such as electrical appliances, batteries, light bulbs and fluorescent bulbs, paints and lacquers, among others, at specific points intended for this purpose. Subsequently, a roll-out of this project is planned for different locations in the district in order to reach the majority of Quitenians.

The municipality will also offer, as a new service to citizens, several collection points for the delivery of batteries and/or used cooking oil.

The trajectory towards a circular economy needs the strengthening of industrial and civic co-responsibility to achieve separation at source of organic, inorganic and recyclable materials.

In the MDQ there are 54 municipal markets, which produce about 70 tons of organic material per day. The Secretary of the Environment plans to implement the following in conjunction with EMASEO-EP, EMGIRS-EP and the District Commercial Coordination Agency:

- Separation of organic material in market collection centers.
- Differentiated collection of organic material.
- Operation of a municipal composting system.
- Commercialization of biological fertilizer produced from the markets' organic waste.

This initiative was implemented in the Wholesale Market of Quito in 2015 and has facilitated the separation and utilization of organic waste, as well as the inclusion in this activity of 55 waste pickers.

Special, hazardous, hospital and medical waste and debris

Sanitary waste

The category of special waste, hospital waste and debris demonstrates the need for current and possible treatments requiring special authorized collection.

EMGIRS-EP operates a plant for the treatment of hospital waste with three autoclaves and two boilers with a capacity of 24 tons/day, which eliminates the biocontamination of microorganisms, viruses and bacteria, leaving inert material for subsequent deposit in the landfill site (*Figure 6*).

Photo: Metropolitan News Agency

Hospital waste

Waste from urban fauna

Currently, EMGIRS-EP is testing a crematorium, where infectious animal waste (urban fauna) is burned. The plant is designed for five tons/day addressing the need for final disposal of dead animals on the district's road.

Figure 6. Treated hospital waste to 2015

Tips

The municipality is planning and designing sustainable waste tips, where materials are recovered from the rubble delivered. In the future it is intended to establish the reuse of materials produced by the demolition of buildings as an obligation for more sustainable constructions. Presently, the city of Quito delivers 3,115 m^3/day of rubble to the municipal tips. Currently the municipality operates two tips, Troje 4 and Piedras Negras, with a new model that allows technical management of the final dis-

posal of municipal solid waste, avoiding generating danger to public health and safety and caring for the environment during operation and after closure of the tip. The new management model for municipal tips includes parking for vehicles, signage, guard security and control, dining facilities, communication and security systems, sanitary facilities, electricity, and other services.

The Piedras Negras municipal tip was opened in the parish of Pifo, with a capacity of 683,929.7 m^3 and a life span of two years. Operations began on May 11th 2015. The site for the final disposal of debris from construction, demolition and civil works, earth excavation, wood, ferrous materials and glass mixed with debris, ash from volcanic eruptions and scrap of all kinds was located in the Los Chillos valley and Tumbaco. The Piedras Negras tip complies with the technical conditions for the activity of debris disposal in a former quarry located in the western foothills of the Cordillera Real mountain range.

For its part, the El Troje 4 tip in the south of Quito has a capacity of 3,030,000 m^3 and operates using the same model.

Decentralization of waste collection in rural parishes

The Municipality of the MDQ is designing more efficient processes for parish Autonomous Decentralized Governments (ADGs), including a possible strategy for decentralized waste facilities aimed at more sustainable operations.

The decentralized system implements separation at source, where recyclable material is commercialized, organic material used for organic gardens, as fertilizer or for energy use (biodigester), and non-recoverable waste is compacted and transported to its final destination, the landfill site.

Currently, in accordance with Metropolitan Ordinance No.332 through an agreement signed by the presidents of parish councils, waste collection activities have been decentralized in seven rural parishes.

Landfill

The MDQ landfill site is located 45 km from the city of Quito, in a high impact industrial area in the El Inga sector, between Pifo and Sangolquí.

The solid waste disposed in the MDQ landfill site arrives mainly from Quito's North and South Transfer Stations; however, the landfill site also receives loads of solid waste from the Municipality of Rumiñahui and from authorized private managers.

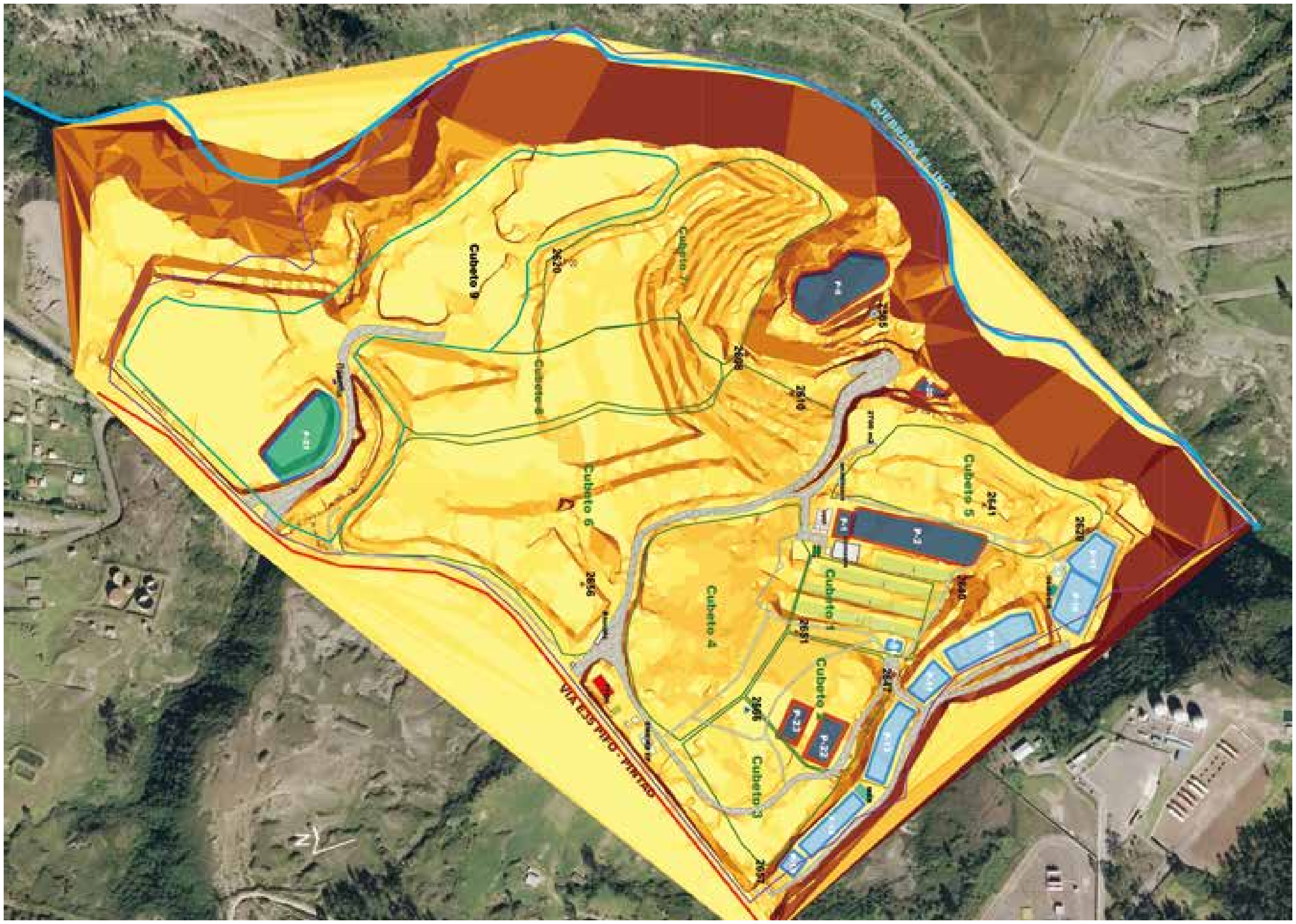
Quito's landfill site aims to treat and dispose of municipal solid waste in a technical and controlled manner to minimize risks, social disruption and environmental impacts.

The landfill site began operations in January 2003 under the direction of the 'Life for Quito' Foundation, which was in charge of the Natura Foundation. In December 2010, the Municipality of Quito created the Metropolitan Public Company for Solid Waste Management (EMGIRS EP), in order to assume the operation of the landfill site and transfer stations.

The El Inga landfill site has a total area of 56 hectares, of which 8 hectares are forested embankments of the Inga river and 48 hectares are for landfill (*see Infographic 5*). The distribution of the different areas within the landfill site is as follows:

40 hectares of the landfill site have been used in the following manner:

- Landfill cells 1 to 8
- Leachate storage pools
- Three leachate treatment plants
- Hospital waste treatment Plant
- Incineration plant for urban fauna



Infographic 5. *Landfill site of the Metropolitan District of Quito*
(Source: EMGIRS-EP)

- Power generation plant using a biogas capture system
- Administrative offices
- 8 hectares are destined for the construction of storage tank 9 which will enable an additional service life of 4.5 years.

Procedure for the disposal of waste in tanks

The operational methodology of the Metropolitan District of Quito's landfill site includes the construction (excavation) of a technically configured storage tank for the final disposal of solid waste, covered with a geomembrane made of high strength

waterproof plastic which protects the soil from the filtration of leachates and biogas. The landfill cells are technically designed with consideration for the following aspects:

- Groundwater management
- Geological and geotechnical characteristics of the soil
- Simplicity of operation
- Leachate management
- Extraction of biogas

The procedure for the disposal of waste in landfill cells includes the following steps:

Disposal site preparation: The work necessary to prepare the area where solid waste will be placed within the operating storage tank; this area is known as the daily cell and is determined by the operator. In the preparation process the surface layer of earth is removed so that the new layer of waste can be deposited directly onto the layer of debris previously covered and thus one single compact mass of waste is formed without layers of earth in between.

Arrangement and conditioning: Refers to the homogeneous disposal of waste in layers of no more than 60 centimeters, using a tractor and/or landfill compactor. It is necessary to ensure the adequate compaction of the mass arranged to avoid cell stability problems.

Covering and final conformation of the cell: Once verified that the cell is formed correctly, a tractor, with the support of a backhoe, covers the garbage with a layer of soil at least 35 centimeters thick, this material must be deposited at the site by the tractor or backhoe, transported and stocked daily on the workface.

Final conformation refers to the final refining of the cell using a motorized grader and its subsequent compacting, performed using a compacting roller to achieve the required compaction of the covering layer and subsequently forming the constructed cell.

Conformation and final covering of a terrace: A terrace is constituted of two or more levels of a series of daily cells, whose total height is about 5 m, and whose width and length, depending on their height, is specified in the final design plans. After completing a terrace, the motorized grader arranges the final covering material (50 cm thick) and the compacting roller ensures compaction with the final conformation of the terrace according to the instructions issued by the contract auditor or its delegates (EMGIRS-EP, 2016).

Leachate treatment

The percolated liquid produced by the decomposition of garbage's organic waste is known as leachate. Leachate in garbage is also formed by the amount of moisture present and by precipitation from rainfall in the landfill cells for garbage disposal.

Leachate generated in the landfill cells is stored in pool 9 for later recirculation into the pools that feed the different leachate treatment systems and finally the treated wastewater is discharged through pool 19 to the Inga River, as shown in the following photographs.

Leachate treatment plants

- MBR treatment plant leachates. (System of Membrane Bioreactor and Reverse Osmosis. At present this plant is in the process of repowering with a nominal treatment capacity of $100m^3$/day).
- VSEP leachate treatment plant (Plant System of Filtration and Reverse Osmosis, installed in 2013, operated by EMGIRS-EP since January 2015, with a nominal treatment capacity of $300m^3$/day).

Photos: EMGIRS-EP

Pools of accumulated leachate

MBR treatment


VSEP treatment


PTL treatment

In 2015, the equivalent of approximately 78 Olympic pools of leachate was treated (195,789 m^3)

- PTL leachate treatment plant (Plant System of Physical Treatment by filtration and sedimentation and Chemical Treatment by leachate flocculation and coagulation, operated by the Villacapria company from December 2015 to November 2017, with a nominal treatment capacity of $200m^3$/day).

Other mechanisms applied to the 'leachate' byproduct are intensive aeration and activated sludge treatment. The outcome of these treatments is water in optimal conditions meeting the parameters required by current environmental regulations.

The daily average leachate generation is 360 m^3 and the operational capacity of the treatments mentioned is a daily average of 536 m^3, for which reason all the leachate generated can be treated, progressively reducing the existing liabilities in the 17 current pools.

Table 1 and *Figure 7* show that the treatment of leachates produced in the El Inga landfill site exceeds production.

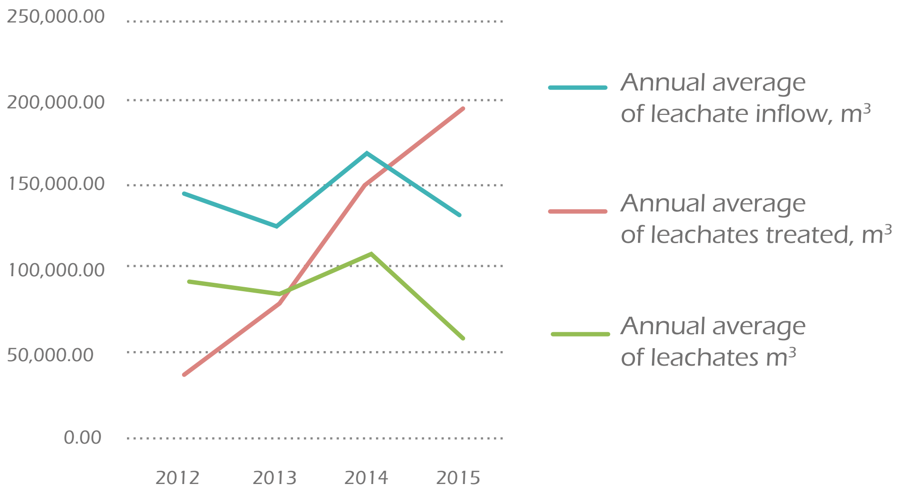


Figure 7: Production and treatment of leachates in the El Inga landfill site
Source: EMGIRS-EP

Table 1. Treatment of leachates by year

Treatment of leachates	2012	2013	2014	2015
Annual average of leachate inflow, m^3	143,821	124,728	168,019	131,508
Annual average of leachates treated, m^3	38,577	80,559	151,819	195,789
Annual average of leachates m^3	91,901	85,907	108,343	60,541

Source: EMGIRS-EP

What happened to the leachates?

When the operation of the landfill started, there was no system for the treatment of leachates generated by the biodegradation of deposited organic waste. In 2008, the MBR treatment plant was installed and treated a daily average of 100 m^3, which did not cover the demands of daily leachate production, resulting in the construction of storage pools. In December 2012, with the implementation of the VSEP plant, and again in 2014 with the PTL treatment plant, treatment volume was increased to meet daily production and process the leachates collected in storage pools. As such the volumes of collected leachates in the landfill site has diminished and the pools have been closed.

In 2015, an average of 30% of generated biogas from the landfill cells in the Inga landfill site was captured

Generation and capture of biogas

Biogas (LFG emissions) is another byproduct of the decomposition of organic matter in landfill sites. The collection system for biogas produced in the landfill site is performed by creating perforated wells in which high-density polyethylene pipes are inserted that capture the biogas produced with a methane content of 46%, 16% CO_2 and 38% of other greenhouse gases.

Methane pollution is 24 times higher than CO_2 and can be exploited. For this reason, EMGIRS-EP installed two 1 MW generators for the utilization of the methane energy (biogas) captured.

The energy recovery plant began its electricity production testing phase in January 2016. During that month, the two engines went through various tests and calibrations to reach optimal production and operation.

Table 2: Monthly value of clean energy generated

Electric energy produced per month [MW/month]	1.8
Methane emission equivalent to CO_2	8,400
Efficiency average [%]	92%
Biogas transformed to electricity per month [m^3/month] [t CO_2]	780,000
Households in Quito benefitting from clean energy	10,000

Source: EMGIRS-EP

Table 2 expresses the values of electricity production in the test phase, the amount (volume/ month) of biogas needed for such production, the conversion of methane to CO_2 equivalent, and the average efficiency of the generators. It must be taken into account that these are the values of the testing stage.

Waste management also protects the climate due to its great potential in the reduction of greenhouse gasses.

In the 'El Inga' landfill tanks, according to EMIGIRS-EP, 500 m^3/hour of biogas are captured for each MW installed. The biogas in the landfill cells contains approximately 46% methane, 16% CO_2, and 38% of other greenhouse effect gasses. Methane is 21 times more polluting than CO_2; this means that for each MW produced there is a reduction of approximately 4,830 m^3/ hour.

At the beginning of 2016, two generators with 1MW capacity each were installed with the ability to capture and use around 230,000 m^3/day of methane gas. The energy produced is integrated into the interconnected national system. Currently, the Secretary of the Environment and EMGIRS-EP are analyzing the possible creation of facilities for five MW at the landfill site.

Policy for natural heritage management

> "To promote the environmental sustainability of the territory guaranteeing the eco-systemic services provided by natural heritage, promoting understanding, sustainable management and the contribution made to the urban-rural fabric." (Metropolitan Ordinance 041, enacted on February 22, 2015).

The policy for natural heritage management in the district focuses on the protection, recovery and sustainable use of spaces containing native vegetation cover, an area of the district exceeding 300,000 ha. Approximately 50% of this area is part of the Metropolitan System of Protected Areas, a strategy for safeguarding ecosystem functionality and maintaining environmental services which are threatened by, among other factors, changes in land use and the growth of urban sprawl.

This policy also involves improving the 'Green Network' in the urban-rural fabric through processes for reforestation and intervention in ravines, areas affected by forest fires and urban greenery, which require citizen participation activities for their implementation.

Figure 8 presents the objectives and the main strategic lines of action related to natural heritage policy.

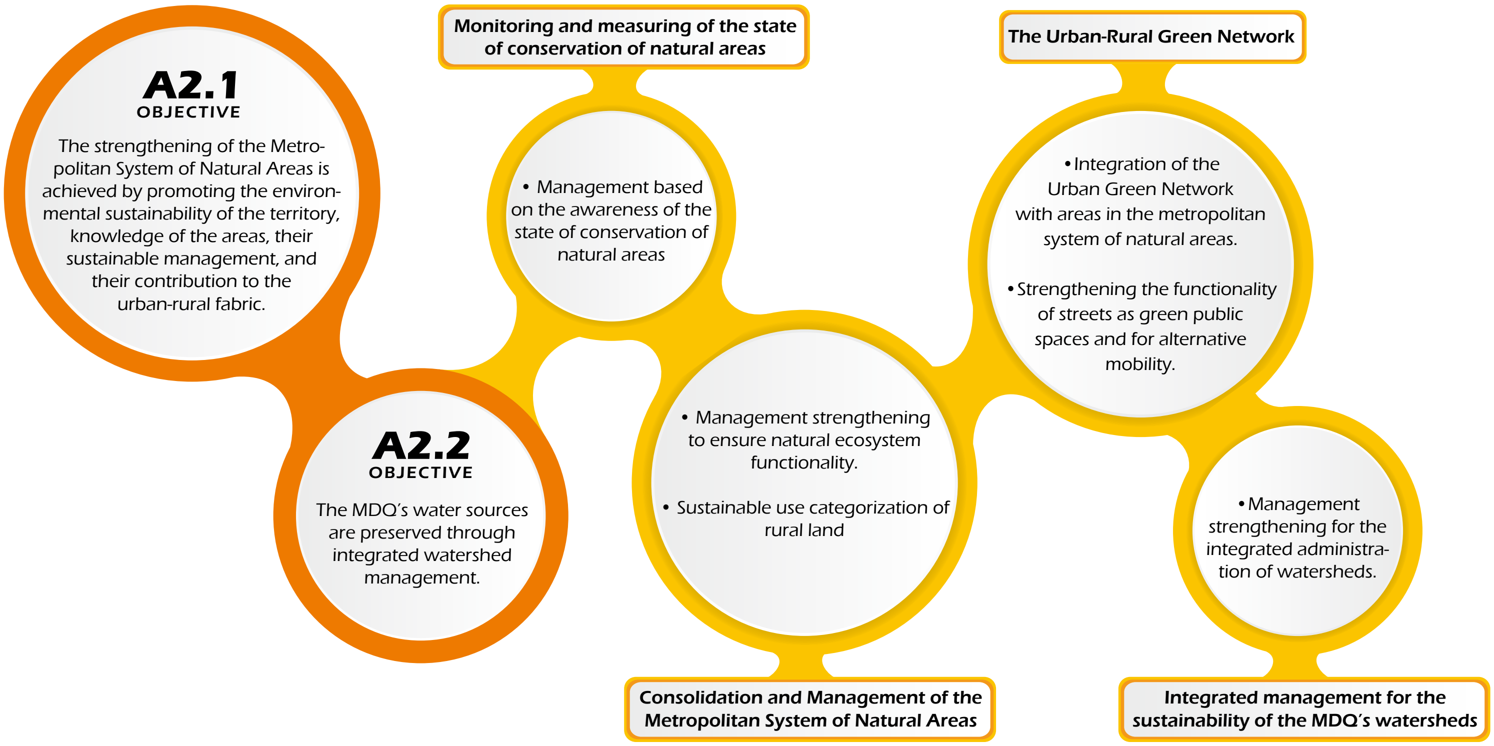


Figure 8. Strategies related to Natural Heritage policy

Photo: Drone & Gis

Pacto parish, in the north-west of the MDQ.

Natural Heritage Management

Metropolitan system of Protected Areas ACUS (Area of Conservation and Sustainable Use)

In the world there is strong pressure for the use of natural resources, which affects ecosystems, and therefore threatens the basis for the existence of biodiversity and the survival of human beings. The best tool to protect ecosystems, biodiversity, and the health and welfare of humanity is the creation of protected areas.

The benefits provided by conservation systems for protected areas range from mitigation and adaptation to the effects of climate change, business opportunities through, for example, tourism, to the maintenance of environmental services on which life on the planet depends.

As such, the Municipality of the Metropolitan District of Quito created the Subsystem of Protected Natural Areas, which promotes conservation and sustainable use of resources, and the knowledge and appreciation of these areas within the district.

Map 1 shows the protected areas of the MDQ and in *Table 3* the area, category and other characteristics of the protected areas that currently form the Metropolitan Subsystem of Protected Areas are detailed.

People's participation is key in all phases of the management model provided by the Secretary of the Environment of the Municipal MDQ for the subsystem's protected areas: design, promotion and management, phases with which the different conservation units must conform. Municipal Ordinance No. 213 states that the process of creating a protected area is faculty of the municipality; however, the possibility exists for a community to request the creation of such an area.

Among several cases evidencing citizen participation in the management of protected areas, which facilitates the identification of problems and environmental needs in the territory, are the management committees formed in Mashpi, Pachijal and the Andean Bear Corridor.

The process of structuring the strategic plan for the Subsystem of Protected Natural Areas of the MDQ places special emphasis on the development of mechanisms to strengthen the management committees of the various protected metropolitan areas; these must be valid mechanisms for making community empowerment the basis for achieving the proposed conservation goals.

Strategic Plan for Protected Metropolitan Areas

The analysis of conservation gaps and priorities is a fundamental tool for supporting effective conservation management of biodiversity in a territory.

The Metropolitan District of Quito (MDQ), with an area of 423,074 ha, has an extraordinary biodiversity and ecosystem. However, the territory of the MDQ has been shaped by socio-economic dynamics that have generated complex landscape mosaics, which in turn involve multiple challenges for the effective protection of biodiversity. The gap analysis of biodiversity conservation, based on the analysis of biological inputs (503 species) and ecosystems (17 remaining ecosystems), identified the sites of biological importance for the MDQ and the major conservation gaps. Based on this, prioritization of areas that need more attention from the municipal environmental authorities is proposed.

Identifying areas of importance for biodiversity in the MDQ was based on the definition of conservation goals that consider ecosystem remnants, the wealth of species, and relevant records of species available to the metropolitan district. These areas of biological importance cover an area of 147,943 ha

distributed mainly in Lloa-Nono, Nanegal-Nanegalito-Gualea, Pacto, Mount Puntas, Píntag and the dry forests and shrublands located between San Antonio and Guayllabamba. Of this area, 43% (63,853 ha) is already under some form of management within the MDQ Metropolitan Subsystem of Protected Areas (MSPA), 10% (15,223 ha) is in the process of becoming so, and an additional 4% (6,348 ha) is under the protection of the Heritage of Natural Areas of Ecuador (HNAE).

Furthermore, four areas have been identified as the major conservation gaps in the MDQ, in terms of ecosystem representativeness and internal and external connectivity: the forests of the Lloa valley, the paramo moors of Píntag, the border between Pacto and Gualea, and the dry forests and shrublands between San Antonio and Guayllabamba, areas covering a total surface area of 62,520 ha.

From this analysis, the promotion of actions for the protection and management of biodiversity in three areas considered of high conservation priority for the MDQ is recommended, including: the northeastern forests and dry shrublands, as these ecosystems are not already under the protection of any of the district's protected areas and are, ultimately, the only alternative for connectivity between dry areas and the eastern wetlands and paramo moors of Mount Puntas. The Lloa valley and the paramo moors of Píntag should also be prioritized due to their biological importance and the integrity of the remaining areas of natural vegetation, and also due to their role as a connecting passage to the areas outside the MDQ HNAE. In addition, we must recognize that each priority area faces different local contexts and achieving their conservation and management involves promoting concerted actions between local people, parish governments and units of municipal management, for their subsequent incorporation into the MSPA (*Map 2*).

Citizen participation in the management of protected areas

Quito, land of bears

According to the Red Book of Mammals, the Andean (spectacled) bear is in danger of extinction in the country. It is estimated that this bear's population has been reduced by approximately 25% as a result of habitat loss and hunting. It is currently believed that there is a population of 45 Andean bears in the cloud forest in the northwest zone of the Metropolitan District of Quito.

One of the strategies for the conservation of the spectacled bear was the declaration of the Andean Bear Corridor. With the support and coordination of the Secretary of the Environment, the San Francisco de Quito University and local residents in the corridor's area, this initiative seeks to ensure the survival of this species and many other species that live in its habitat.

In 2014, the Secretary of the Environment, with the active support of a group of inhabitants in the northwest of the MDQ, created the Andean Bear Conservation Program (ABCP) for the 5 years from 2014 to 2019, with 16 objectives, 33 activities and 58 sub-activities referred to in 5 lines of action: 1) research and monitoring, 2) prevention, control and surveillance, 3) education and communication, 4) sustainable production alternatives, and 5) local inter-institutional management. This program is a roadmap of actions intended to protect the Andean bear, an emblematic species of Quito, and along with it, associated biodiversity in the habitat of the forests of the northwest.

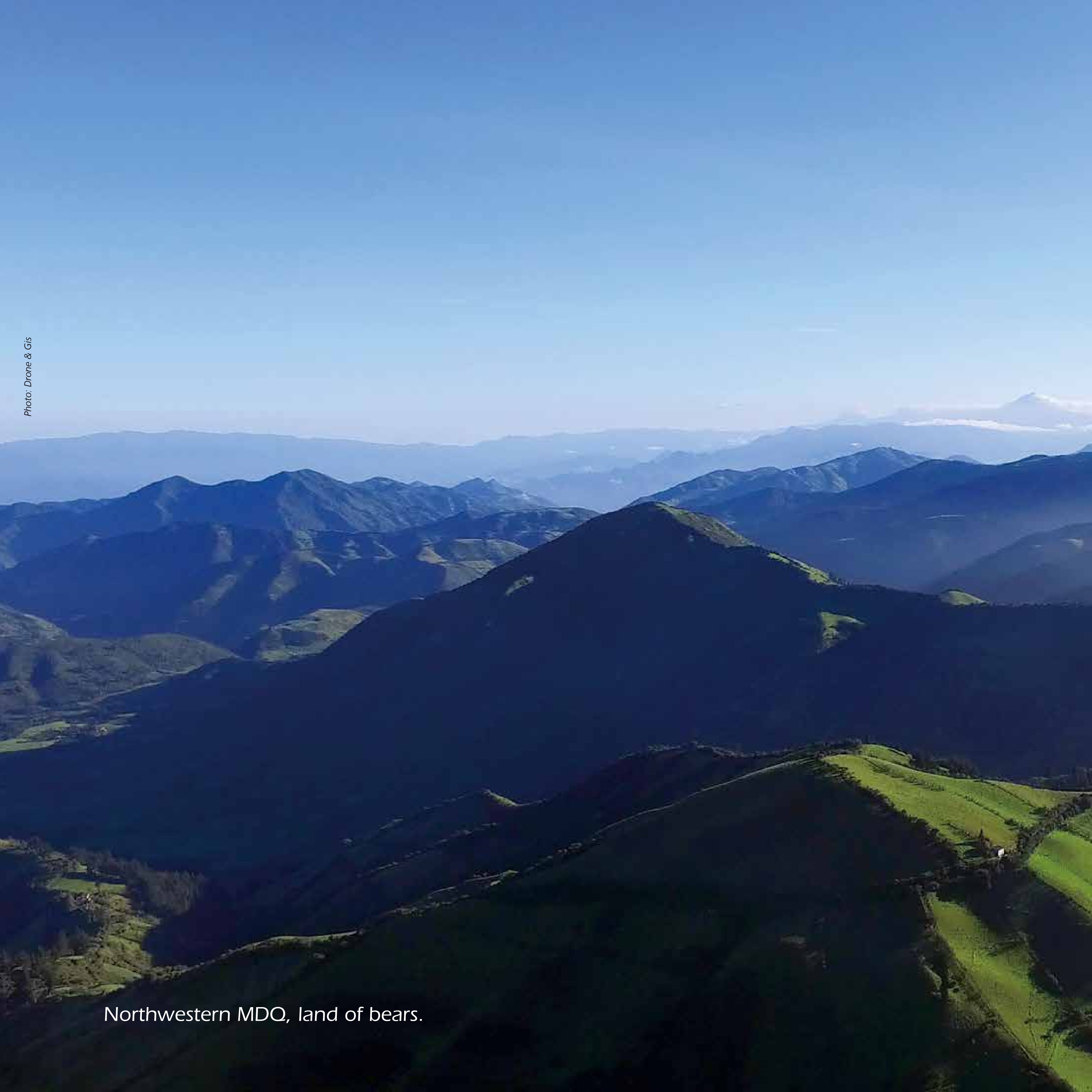
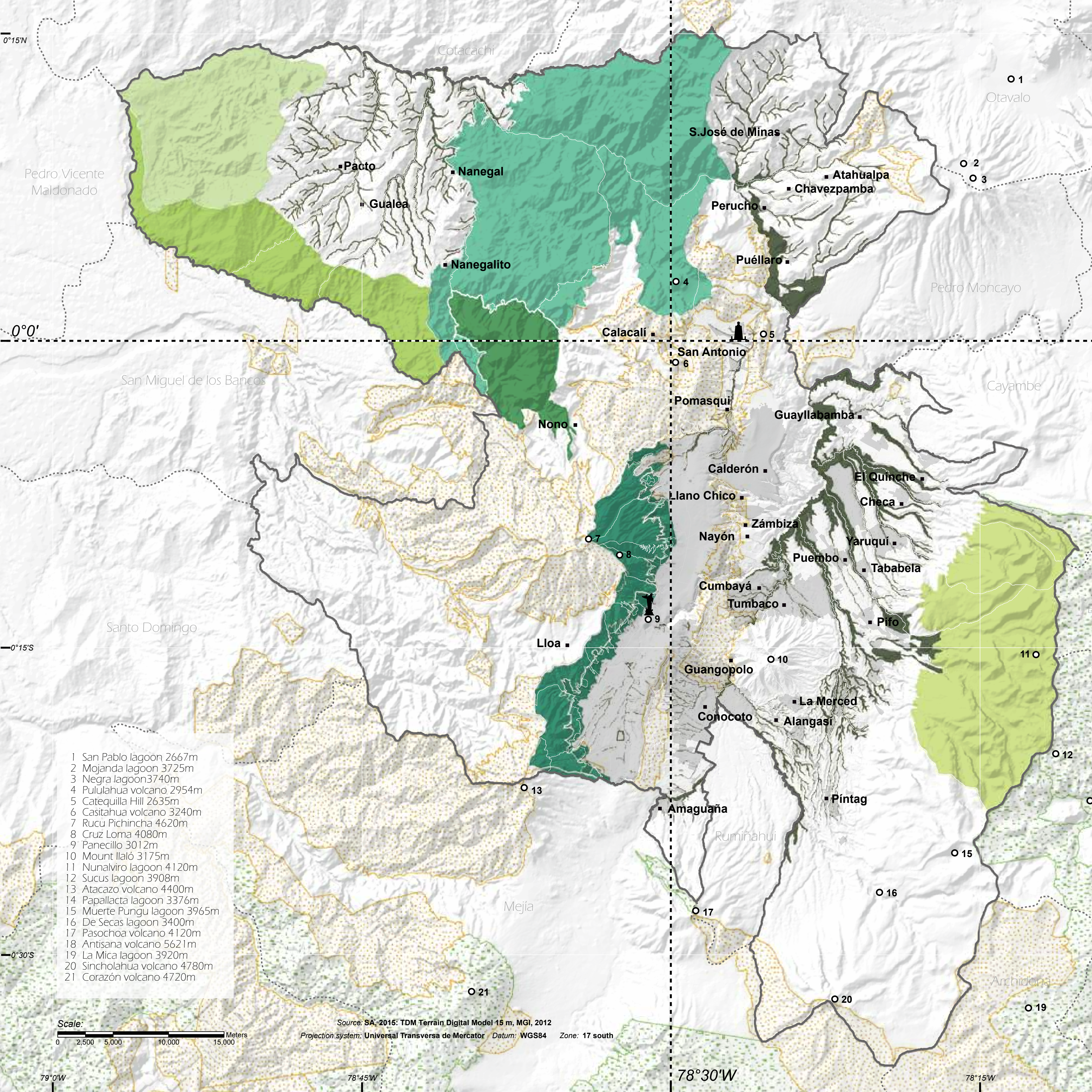


Photo: Drone & Gis

Northwestern MDQ, land of bears.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Otavalo
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S.José de Minas
Pacto
Nanegal
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Chavezpamba
Gualea
Perucho
Puéllaro
Nanegalito
Pedro Moncayo
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Calacalí
San Antonio
San Miguel de los Bancos
Cayambe
Pomasqui
Guayllabamba
Nono
Calderón
El Quinche
Llano Chico
Checa
Zámbiza
Nayón
Yaruquí
Puembo
Tababela
Cumbayá
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Pifo
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Guangopolo
La Merced
Conocoto
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Píntag
Amaguaña
Rumiñahui
Mejía
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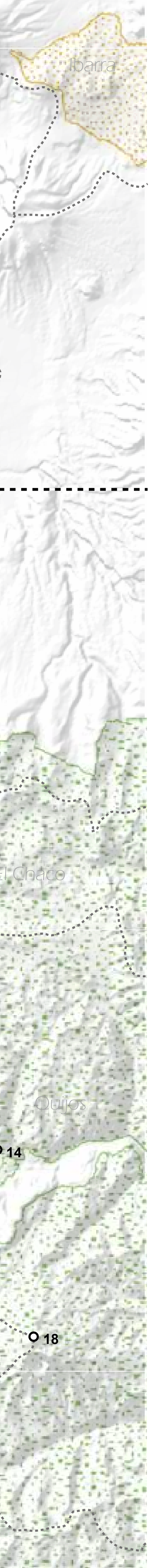
Archidona
1 San Pablo lagoon 2667m
2 Mojanda lagoon 3725m
3 Negra lagoon3740m
4 Pululahua volcano 2954m
5 Catequilla Hill 2635m
6 Casitahua volcano 3240m
7 Rucu Pichincha 4620m
8 Cruz Loma 4080m
9 Panecillo 3012m
10 Mount Ilaló 3175m
11 Nunalviro lagoon 4120m
12 Sucus lagoon 3908m
13 Atacazo volcano 4400m
14 Papallacta lagoon 3376m
15 Muerte Pungu lagoon 3965m
16 De Secas lagoon 3400m
17 Pasochoa volcano 4120m
18 Antisana volcano 5621m
19 La Mica lagoon 3920m
20 Sincholahua volcano 4780m
21 Corazón volcano 4720m
Scale:
0 2,500 5,000 10,000 15,000 Meters
Source: SA, 2015: TDM Terrain Digital Model 15 m, MGI, 2012
Projection system: Universal Transversa de Mercator Datum: WGS84 Zone: 17 south
79°0'W
78°45'W
78°30'W
78°15'W



Map 1

MDQ District System of Protected Areas

Subsystem of Protected Areas and development projections to the year 2025				
Management category		Name, area and location	Values and related services	Actual state and projected state
ACUS - Area of Conservation and Sustainable Use		**Mashpi- Guaycuyacu- Saguangal** 17,156.00 ha Mashpi, Guaycuyacu, and Saguangal river basins in the north-west area of the district, Pacto Parish.	• Protection of the remnants of ecosystems in the Chocó bioregion and of the water sources in the northwestern MDQ. • Nature tourism development • Development of systems	• High level of participation of the local management committee • Expected strengthening of the area's management committee • Application of good agricultural practices in systems of agro production • Maintenance and recovery of native forest
ACUS - Area of Conservation and Sustainable Use		**Area of Conservation and Sustainable Use. Pachijal Water and Archeological System** 15,882 ha Pachijal high and middle river basin on the boundary between the MDQ and Canton San Miguel de los Bancos. Nanegalito, Gualea and Pacto parishes	• Protection of the remaining ecosystems of the Chocó bioregion and of the water sources in the northwestern MDQ. • Nature tourism development • Development of sustainable livestock systems • Functional connection between low and high northwestern areas • Protection of archeological sites	• Expected strengthening of the PA's management committee. • Improvement of crop and livestock systems through the application of good practices
ACUS - Area of Conservation and Sustainable Use		**Yunguilla** 2,981 ha Tanachi and Pichán river basins. Calacalí parish	• Protection of the remnants of montane ecosystems in the western Andes. • Nature tourism development • Development of sustainable crop and livestock systems • Functional connection as part of the Andean Bear Conservation Corridor	• The community has participated in research supporting the extension of the ACUS to include 10,000 additional hectares • The extension process is expected to be completed in 2016
APH - Area of Wetlands Protection		**Mount Puntas** 28,218 ha Systems of rivers and ravines in the western MDQ, western paramo moors adjoining the Cayambe-Coca National Park. El Quinche, Checa, Yariquí and Pifo parishes	• Protection of water sources • Regulation of the use of natural resources associated with the paramo moors	• The plan for management together with Fonag is being developed. • Partnerships with the Autonomous Decentralized Governments of the Checa, Yaruquí, El Quinche and Pifo parishes and local populations will be strengthened
AIER - Area of Special Intervention and Recovery		**Pichincha-Atacazo** 23,454 ha Paramos in the west of Quito, headwaters of the Machángara and Monjas river basins, Condado and Guamaní parishes.	• Protection of the western Paramo moors of Quito • Protection of water resources for Quito • Control of urban development on the Pichincha volcano's foothills	• An expected possible extension of the area towards the headwaters of the Saloya, Cinto and Pichán rivers in order to complement the protection of Quito's western water sources.
Andean (Spectacled) Bear Corridor		**Andean Bear Corridor** 61,573 ha. Branches of the Andean mountain range between San José de Mina and Nono. Calacalí, Nanegalito, Nono, San José de Minas, Puéllaro and Perucho.	• Protection of the Andean forests known to be the Andean Bear's habitat. • Regulation of existing production activities (mainly livestock) • Promotion of low environmental impact economic activities, alternative activities and better livestock practices	• Execution of the Andean Bear Program, which has a final deadline of 2019

Table 3. Overview: Six Metropolitan Protected Areas

Total surface area with a management category: 146,283 ha (the Yunguilla ACUS surface area is included in the Andean Bear Corridor).
By 2025, it is planned to incorporate into the Subsystem a section of the montane forests west of Lloa, the Inter Andean forests of Mojanda, the paramo moors in the south-east of Quito, and the remnants of Inter Andean dry vegetation associated with the Guayllabamba, Chiche, and San Pedro canyons.

ACUS Mashipi - Guaycuyacu - Sahuanga
ACUS Pachijal
ACUS Nono - Pichán - Alambil
Andean (Spectacled) Bear Corridor
APH Cerro Puntas
AIER Quebradas Vivas
AIER Pichincha - Atacazo
Protected Forests (Ministry of the Environment, MAE)
Protected Areas (Ministry of the Environment, MAE)

Areas of importance for bird conservation (IBAs)

The Areas of Importance for Bird Conservation program internationally recognizes the following IBAs located in the northwest of the Metropolitan District of Quito: IBA EC108 Mashpi-Pachijal, IBA EC043 Mindo and the western foothills of the Pichincha volcano, and IBA EC 042 Maquipucuna-Guayllabamba, with the aim of combining biodiversity conservation and social development with a focus on sustainability, as in these areas there are species of birds which are globally threatened, have restricted ranges or are endemic to the area.

Urban bird census

The Christmas Bird Counts began in the holiday season of 1900, created by ornithologist Frank Chapman in order to preserve the species at risk of disappearing, and proposed to change the traditional countryside hunting tradition for a 'Christmas bird census' in which birds are counted instead of hunted.

In Ecuador these censuses began in 1994 with the First Christmas Bird Count in Mindo, recording 220 species. In the following years the species counted increased until in 2000 Ecuador was ranked in first place internationally with 400 species, maintaining this position in 2006, 2007, 2008, 2009 and 2010.

In the First Urban Christmas Bird Count in Quito, 132 species and 3,373 individuals were recorded, the species with the largest populations being: the Eared Dove (*Zenaida Auriculata*), the Rufous-collared Sparrow (*Zonotrichia capensis*), the Great Thrush (*Turdus fuscater*), the Sparkling Violetear (*Colibri coruscans*), and the Blue-winged Teal (*Anas discors*), a migratory species.

The family with the more recorded species was *Trochilidae* (hummingbirds) with 17 species; additionally 10 species of migratory birds, 5 species of owls and 6 species of raptors (birds of prey) were recorded. This great variety of species, which can be observed in different parks and green spaces of the city, makes Quito a true Bird Garden.

In conclusion, at global level Ecuador has occupied first place in this discipline for 10 years.

The II Quito Christmas Bird Count was organized by the 'Birds of Quito' Bird Watching Group with the support of the Zoological Foundation of Ecuador, Quito Zoo, the Secretary of the Environment, the NGO 'Birds and Conservation', the Bird Network of Ecuador, the San Francisco de Quito University, the Quito Botanical Garden, and the Yaku Water Museum, among others. It was held on the 26th and 27th of December 2015 and a total of 120 species and 4,227 individuals were counted, this record was obtained without cost through the participation of 70 people in 11 pre-established routes.

Model Forest

In 2013, through the efforts of local authorities and representatives of Northwest Quito, Ecuador's accession to membership of this regional network was achieved, the other integrants including: Costa Rica, Argentina, Bolivia, Chile, Paraguay, Brazil, the Dominican Republic, Puerto Rico, Colombia, Peru, Guatemala, Honduras, Italy, Spain and Canada.

A Model Forest is a territory where people organize and participate to manage their forests and other natural resources together, in the pursuit of sustainable development. Model Forests contribute to achieving global targets for reducing poverty, climate change and desertification, and achieving the Millennium Development Goals.

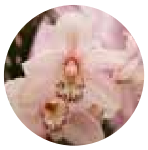
On March 9th 2016, the Ibero-American Model Forest Network (IAMFN), an organization responsible for the development of models of sustainable territorial planning, declared the northwest of the Metropolitan District of Quito to be the 'Andean Chocó Model Forest'.

The Andean Chocó Model Forest is the first forest of this type declared in Ecuador. It has an area of 124,296 hectares and has a population of approximately 18,112 inhabitants, the altitudinal gradient ranges from 500 meters above sea level to 4,700 masl at one of the peaks of the southern Pichincha volcanic complex - east of the parish of Nono. This enormous altitudinal variation and the consequent pedoclimatic variability result in a landscape characterized by a mosaic of natural ecosystems and productive uses.

The declaration of the Andean Chocó Model Forest is the result of sustained work in the ACUS system, by landowners, the Andean Chocó Association of Decentralized Autonomous parish Governments, and of organizations working for the conservation and sustainable use of natural resources in the area.

The scientific and technological workgroup of the convention on Biodiversity, at its meeting in April 2016, recognized the work of three Model Forests - that of Ecuador, one in Canada and one in Africa, as contributing to the objectives of the agreement especially in reference to the recovery of vegetation cover.

Orchids



Due to factors such as geographic location, temperature, light and humidity, about 400 species of orchids have so far been identified in the Metropolitan District of Quito, more than 10% of the country's total species, a true record for a Metropolitan area.

In 2013, Ecuador was declared 'Country of orchids'. Of the 35,000 species of orchids registered in the world, 4,000 are in Ecuador and 600 in the Metropolitan District of Quito.

Cloud forests, ravines and moors guard a treasure, the natural heritage of millions of years of evolution marked by the presence of the Andes, this is a unique Andean District, which keeps surface areas of nature intact, and it is in these areas where orchids abound.

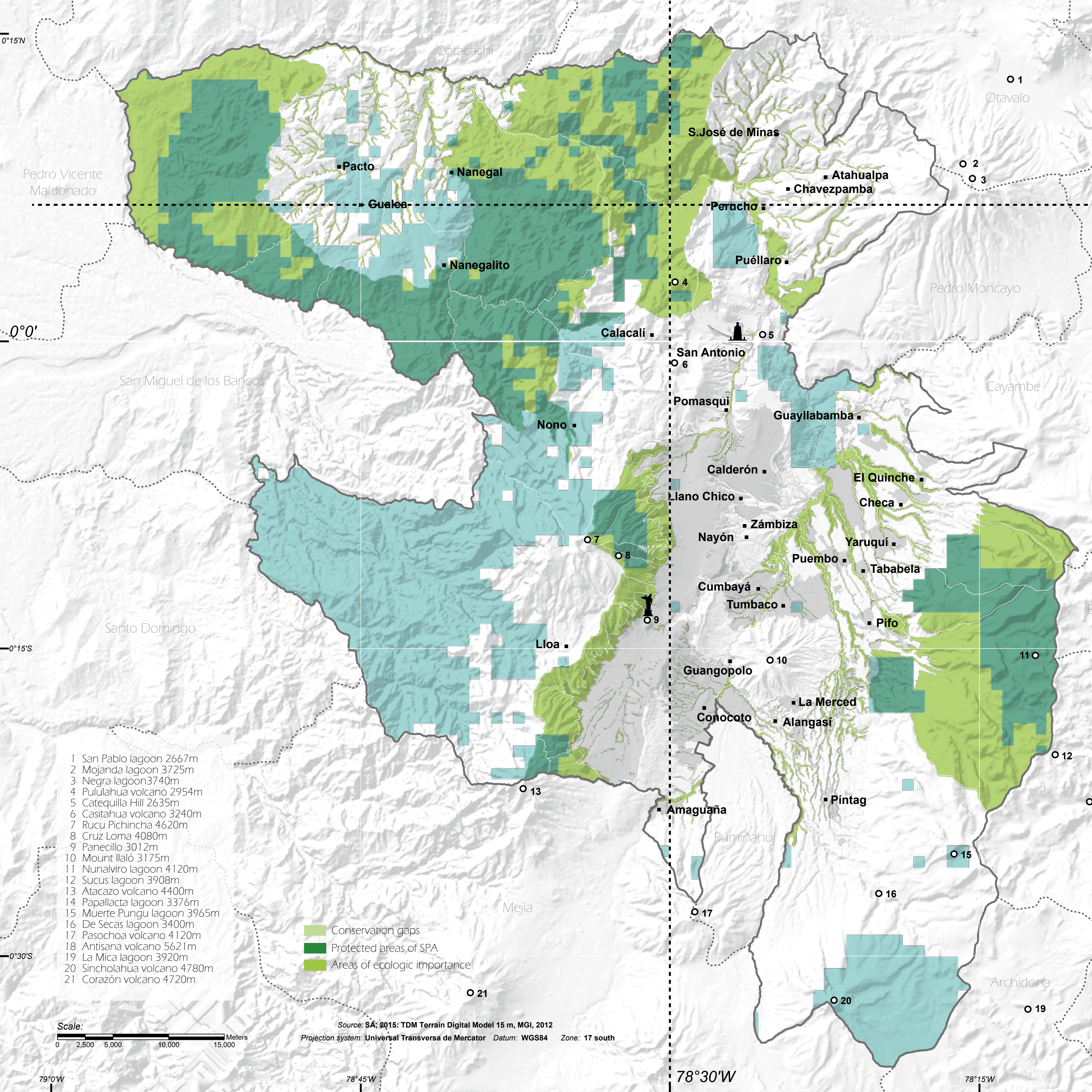
Community Tourism in Yunguilla

"We are a mestizo (mixed-race) community, located in the parish of Calacalí. In 1995 a process of community organizing and environmental conservation was initiated through a forestry development project. The project was supported by an NGO and with the help of international cooperation sustainable productive activities such as organic gardens, small dairy processing plants, jam-making with fruit and ecotourism were implemented. In 2000, the Yunguilla Micro-business Corporation was founded, as a community organizational entity. In 2010 and 2013, with the support of the Ecofondo Foundation, Yunguilla was declared an Area of Conservation and Sustainable Use within the System of Protected Areas of the Metropolitan District of Quito."

About 300 people live in Yunguilla. Twenty years ago, the community decided to change its lifestyle from one which cut down trees to make charcoal to one which preserves the environment.

Currently, the 52 families who are part of the project open the doors of their homes and provide an opportunity for cultural immersion to tourists. They are spacious and comfortable houses, made with wood and tiles; they have hot water, kitchens and complete rooms for the rest and relaxation of tourists.

The community also offers eco-tourism opportunities like hiking through native forests and on the culuncos trails (pre-Inca paths that look like carved deep ruts in the soil), bird watching, and participation in micro-projects related to the preparation of dairy products, jams and crafts.



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Nanegal
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Nanegalito
Pedro Moncayo
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Calacalí
San Antonio
San Miguel de los Bancos
Cayambe
Pomasqui
Guayllabamba
Nono
Calderón
El Quinche
Llano Chico
Checa
Zámbiza
Nayón
Yaruquí
Puembo
Tababela
Cumbayá
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Guangopolo
La Merced
Conocoto
Alangasí
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Amaguaña
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19 La Mica lagoon 3920m
20 Sincholahua volcano 4780m
21 Corazón volcano 4720m
Conservation gaps
Protected areas of SPA
Areas of ecologic importance
Scale:
0 2,500 5,000 10,000 15,000 Meters
Source: SA; 2015: TDM Terrain Digital Model 15 m, MGI, 2012
Projection system: Universal Transversa de Mercator Datum: WGS84 Zone: 17 south
79°0'W
78°45'W
78°30'W
78°15'W

Map 2 Areas of Biological Importance in the MDQ

ABI: 35% MDQ
(Areas of Biological importance)
147,944 ha

47% of ABI
are protected 70,201ha

53% of ABI
77,743ha
are unprotected

15,223ha+ of ABI
in the Pichán-Alambí and Ilaló-Lumbisí initiatives

Zonal Administration	ABI (ha)	% inside of the PA
La Delicia	70,562.72	67.12
South - Eloy Alfaro	40,195.77	3.36
Tumbaco	16,588.63	83.18
Los Chillos	11,504.35	0.97
North – Eugenio Espejo	6,649.15	98.39
Calderón	1,734.58	18.09
Quitumbe	607.62	84.61
Center – Manuela Sáenz	100.84	0.01
	147,943.66	**47.3**

The priorities for incorporating unprotected areas are:

- The dry ecosystems of San Antonio, Guayllabamba (Strategy of east-west connectivity and the last remnants in the MDQ)
- The Lloa Valley (western block consolidation)
- The Paramo moors of Píntag (the only southern area and the connector with the Antisana Ecological Reserve and the Cotopaxi National Park)

Source: Secretary of the Environment, 2015. Strategic Plan for the Metropolitan Subsystem of Protected Areas and Ecological Corridors of the Metropolitan District of Quito. Technical Document.

Sunset in Mashpi

Photo: Germán Toaza

All incomes entering the community as a result of tourist visits are placed into a common fund, and then distributed among the project participants (Yunguilla Corporation, 2016).

Coffee

The Municipal government of the Metropolitan District of Quito, through the Secretary of Productive Development and Competitiveness and the Metropolitan Economic Development Agency, Conquito, has worked on the creation of a coffee production chain in the 'Quito Coffee' project.

The northwestern district is an area with high potential to establish coffee plantations aimed at different markets. The parishes of Pacto, Gualea, Nanegal and Nanegalito have adequate climates for producing various types of coffee.

The project seeks to consolidate a sustainable production model for rural parishes in the northwest, implemented with the support of the Municipality of Quito and the various public and private institutions related to the 'Quito Coffee' project, to improve productivity and the incomes of coffee producers.

Coffee currently occupies 40% of the agricultural area in the northwestern district and contributes 27% of agricultural income and 11.6% of total revenues in the area.

Today, there are around 58 coffee producers, most of which are organized into four associations: AAPROC-CNOP, AAPROCAFEP, ASOPROCEP and ASCAFEN (Mashpi Shungo, 2016).

Chocolate

In the parish of Pacto, in the Mashpi community, on the Mashpi Shungo farm, one of the best artisan chocolates is grown and produced.

Mashpi artisan chocolate is proud to use the best cocoa in the world; the seeds of the renowned National Fine Aroma Cocoa are the raw material for producing the most aromatic and tastiest chocolate.

In addition, cocoa is grown within a completely organic agroforestry system in areas where previously forests were destroyed, allowing the restoration of these areas. The entire production process, from planting to harvesting and packaging, takes place on the Shungo Mashpi farm.

The aim is to perpetuate traditional forms of sustainable agriculture, while supporting the sustainability of Ecuador's Chocó region (Mashpi Shungo, 2016).

Under conditions of intensive land use associated with agricultural activities, the coffee and cocoa management systems under shade are good mechanisms to protect the soil and increase connectivity between remnants of native forest.

Recovery of ravines

The territory where the Metropolitan District of Quito is located is dominated by mountains and active volcanoes that permanently shape the landscape and soil structure, with varying levels of precipitation, associated with moisture reaching the inter Andean valley from both the coast and the Amazon region. The district also has a geographical relief dominated by a large number of channels of rivers and streams with generally deep ravines, which constitute the high and middle basins of the Guayllabamba River.

In fact, the large number of streams that flow down from the upper parts of the east and west of the aforementioned river basin are natural ways of channeling and regulating the water that is stored in the paramo moors and the remnants of montane forests.

This natural function is evident in the many streams that maintain seasonal or permanent flows,


Photo: Drone & Gis

Reforestation area, Nono parish

either by surface runoff or by the upwelling of a large number of aquifers.

To this function is added the fact that streams operate as natural links between such diverse ecosystems as, for example, the icy peaks of Sincholagua, the arable paramo moors of southern Píntag, the inter Andean montane forests and dry forest of Guayllabamba, even reaching the subtropical and tropical forests of Gualea and Pacto. That connection is functional if one takes into account that through its associated rivers and streams, a dynamic flow of species of wild flora and fauna can be perceived.

The natural wealth of the ravines and their streams has always been appreciated by the inhabitants of Quito. The various communities that inhabited the territory of the present day MDQ recognized in them a great wealth of medicinal and curative fruit plants; likewise, they knew that the ravines gave refuge to animals such as the paramo moor wolf, the long-tailed weasel, the fox, the partridge, the blackbird, the rabbit, the skunk, the armadillo, the puma, the Andean bear, the wildcat, the hummingbird and the dove, to name a few.

Today, however, these environmental services are in a process of deterioration: the streams come from population centers, urban and suburban neighborhoods; a large amount of water is contaminated and cannot be purified naturally.

The partial and total filling of ravines to hold the sewage system and facilitate road connection between urban areas forms an almost insurmountable barrier to wildlife.

The native vegetation of chilca, myrtle, pumamaqui, cholán, marco, banana passionfruit, carob, to name a few species, are being displaced by the Kikuyu, eucalyptus, acacia, the lime tree and countless garden plants, deposited in the ravines by neighbors who consider them to be rubbish dumps.

Finally, the people who recognize the traditional uses of plants growing in the ravines are becoming fewer, and even less are those who value wildlife species like the green snake, the marsupial frog, the beetle, the fox or the kestrel.

The situation described above is summarized by the loss of quality of life for residents of the ravines of the MDQ, manifested by a large number of citizen requests to different municipal authorities for intervention on this issue. Unfortunately, most of these requests ask for ravines to be filled.

During the first months of 2015 the Secretary of the Environment worked on the Integrated Environmental Intervention Plan for the ravines of Quito, as a technical guide, which classified the ravines of seven sectors of the district and defined the state of natural heritage conservation associated with them, as well as the major issues affecting them.

The Plan identified 182 major streams in the 7 sectors of the MDQ. Based on consultations with environmental leaders of the Zonal Administrations, a list of 33 priority streams was generated, according to the feasibility of intervention for environmental recovery, with special attention given to those in urban areas of the MDQ.

The plan also outlines the guidance protocols for the diagnostics, coordination, intervention, monitoring and evaluation phases. It proposes a scheme for mapping the actors and the management model applicable to the ravines and streams of Quito.

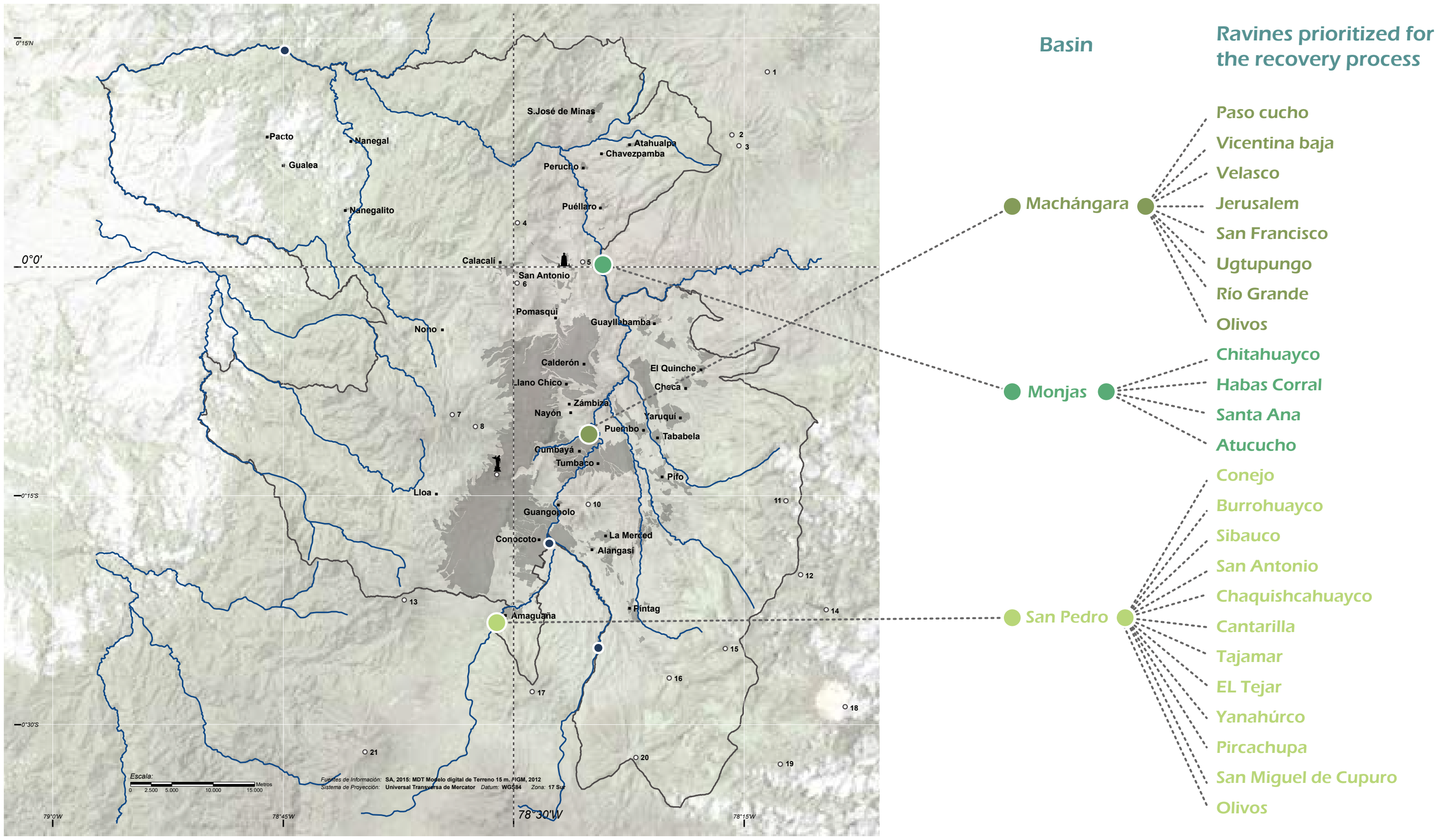
Currently, the Secretary of the Environment is focusing its work on the Zonal Administrations as operating entities in the territory, applying the logic of training-action in order to attend to requests for municipal intervention on the issue of ravines.

Further attention has been paid to working with the following Zonal Administrations, always based on the express manifestation of the residents of the ravines and streams:

- Quitumbe
- La Delicia
- Eugenio Espejo
- Eloy Alfaro
- Tumbaco

The principles and strategies implemented are as follows:

- The identification and analysis of problems, their causes and possible solutions is carried out with local neighbors, Zonal Administration technicians and with the support of technical experts from EPMAPS, EMASEO and AMC.
- The filling of ravines and their streams is not a solution to problems, unless human beings are at risk.
- The ravines are not the cause of bad odors, garbage accumulation or the presence of criminals.
- Removing native vegetation from the ravines does not solve odor problems or crime.
- Garbage, rubble and garden waste clog the channels of ravine streams, create slope instability, and the decomposition of organic material results in odors and the proliferation of rats. The solution to these problems is to eradicate the habit of using ravine streams as waste dumps. Working with local neighbors is important.
- The ravine stream diagnosis must consider its entire course; it is not very practical to recover sections if problems have not been solved, at least in the stream’s upper course.
- Recovery projects for stream recuperation incorporating marginal sewage interceptors are more feasible. Ongoing coordination with EPMAPS is key, especially in relation to ravine streams with sewage systems installed.



Map 3. Ravines prioritized for recovery 2015-2025

With regard to inter-municipal coordination, the Municipality of the Metropolitan District of Quito, through the Secretary of the Environment, has proposed to promote integrated solutions ranging from the establishment of a network of marginal interceptors and the installation and operation of wastewater treatment plants, to the control of the disposal of waste and debris in these natural spaces throughout the Metropolitan District. However, the full recovery of the different streams can only be realized and more importantly maintained over time, when residents recognize their environmental value, relate this value to tangible benefits and take care of the streams in the long term.

Map 3 lists the ravine streams prioritized for recovery processes through coordinated management between the Secretary of Environment, the Zonal Administrations, neighborhood committees, EPMAPS, EMASEO, EMGIRS, EPMMOP, AMC and the various entities demanding ravine recovery as natural environments of high ecological, scenic and recreational value.

Recovery of forests and vegetation cover

In terms of the situation of forest areas, the forest management model, or just forest management in the

MDQ, requires overcoming the difficulty of dispersal of information and the initiatives of unrelated projects, driven by several local, regional and national institutions, which prevents a comprehensive understanding of what should be done, what can be done and the amount of resources available.

In the last 27 years (1986-2013)[1], Quito has lost approximately 29,320 ha of its forest cover at an average of 1,570 ha/year. This is the result of a number of factors such as urban sprawl and the advancement of the agricultural frontier, illegal logging and forest fires, as well as indirect activities such as quarrying, and metal mining and hydroelectric projects. Road construction has also caused the loss of vegetation cover, reflected in the fragmentation of habitats and ecosystems, the population decline and extinction of species of wild flora and fauna, a reduction in the wealth, composition and structure of native forests, and the deterioration of environmental services these areas provide to the population of the MDQ.

In this scenario, the stimulation of sustainable forest management, based on Territorial Management, is urgent for the forests of the MDQ. Thus, it is necessary to clearly define the areas of the district which will benefit from permanent forest protection (protected forests and vegetation, riparian forests, protection and recovery of riverbanks and streams in accordance with current regulations, and areas of steep slopes with risks of landslides and floods). Additionally, it is necessary to locate and establish permanent forest production areas, determined by the sustainable management of native forests, forest plantations with fast growing species and high commercial value, agroforestry, silvopastures and non-timber forest products.

From 2010 onwards, through the management of the Directorate of Natural Heritage of the Secretary of the Environment, recovery processes for plant cover in the district have been developed, under different modalities of intervention. In that year the Recovery Plan for Areas Affected by Forest Fires was created to establish forest plantations in areas that were affected by fire in the summer of 2009. This plan led to the creation of an instrument for the recovery of vegetation cover in a more holistic context: the Forest Management Model. In 2015 the Plan for Vegetation Recovery (2015 to 2019) was developed.

The Forest Management Model (FMM)

Recovery and management of vegetation cover in any territory should not be distant from social, economic, cultural and environmental dynamics. In this sense, the context of the processes for the recovery of vegetation cover is integrated with a landscape and territorial vision.

Thus, the Secretary of the Environment, in order to strengthen the vegetation cover recovery processes, and with the participation of key stakeholders, produced the Forest Management Model (FMM) in 2013 as a technical and strategic tool to direct and strengthen forestry actions in the MDQ, with a comprehensive approach to intervention and a vision of the landscape.

This model takes into account three key processes: the management of native forests, the recovery of vegetation cover, and community forestry. The model is based on the Sustainable Forest Management (SFM) approach, which involves varying degrees of human intervention, ranging from actions intended to safeguard and maintain forest ecosystems and their functions, to actions promoting economically or socially valued species or groups of species to improve the production of goods and services. *Tables 4, 5 and 6* show these three processes, their objectives, strategic lines and key stakeholders.

1 Final report of the process of training and technical advice to beneficiaries of and participants in the process of forestation and reforestation in areas of strategic importance and social interest in the MDQ (2013).

Table 4. Native Forest Process

Process definition	Objectives	Strategic lines	Key actors
Process responsible for the management and conservation of native forests (Humid, Dry, Andean) and fragile ecosystems (Wetlands and paramo moors). Native forest refers to the tree ecosystem, primary or secondary, generated by natural succession and defined by the presence of trees of different native species, ages, varied sizes, with one or more strata.	To promote the conservation and management of native forests as sources of environmental goods and services, with a focus on sustainability oriented towards natural heritage conservation and climate change adaptation and mitigation.	To establish forest regulation as a conceptual framework to perform sustainable forest management. To prevent the substitution of native forest or fragile ecosystems such as paramo moors and wetlands.	Universities: Ecuador Central, Catholic, San Francisco, UTN, EPOCH, Museum of Natural Sciences MAE ('Socio Bosque' program) Ministry of Internal Affairs Provincial Government Environmental Police Metropolitan Commissioner for the Environment Help in Action, Birds and Conservation, International Conservation, Mindo Cloud Forest Foundation

The Secretary of the Environment does not implement specific actions such as the exploitation of wood or forest plantations for production purposes; nevertheless, management by this agency to be implemented with corresponding authorities is important in order to conduct such activities with a technical and strategic focus for the conservation of natural heritage.

Table 5. Process of vegetation cover recovery

Process definition	Objectives	Strategic lines	Key actors
The process responsible for leading the establishment of forests and forest species with the aim of protecting and recovering degraded forest lands, such as the establishment of raw forest materials to supply needs for forest products and sub-products.	To promote forest plantations for the sustainable production, protection and conservation of ecosystems and in accordance with the territorial regulations of the Metropolitan District of Quito. To foster natural regeneration processes, protecting the areas of regeneration from potential pressures (forest fires, changes in the land use, grazing, among others).	To control the size, location and design of forest plantations and their harvesting methods, promoting territorial regulation in accordance with national policies. To ensure compliance with national forest legislation and legislation for the protection of forests against different harmful agents (pathogenic, fire, flooding, among others).	Ministry of the Environment, 'Socio Bosque' Program of Reforestation for the purposes of protection MAGAP; Sub-secretary of Forest Production SENAGUA: Basin protection Project. EPMOP: Unit of Public Spaces, administration of four nurseries EPMAPS: Program for Basin Management.

Table 6. Social forestry process

Process definition	Objectives	Strategic lines	Key actors
The social or community forestry that motivates farmers to fight poverty and satisfy their needs from their farms. Plantations are not considered the only important activities, but rather social forestry includes a range of agroforestry and silvopasture activities. Social forestry seeks "to reinforce the community's and the peasant family's capacities to adequately self-manage their renewable natural resources. These goals are met through the application of a participatory program of forest extension with two axes: promotion and training." (Jordán, 1997).	To establish an organization model aiming to achieve the active participation of all social actors, which will allow the promotion of socio-economic development through the implementation of agroforestry and silvopasture systems and the sustainable community management of natural resources.	To ensure the effective and coordinated participation of civil society, with total cover in terms of territory and affiliation, to favor local well-being, with an emphasis on rural development.	MAGAP, production programs of management, promotion and enhancement in social forestry MAE: programs of conservation Universities: strategic alliances to collect and produce information. International cooperation: support in the elaboration of programs and projects, and financing. Communes: to manage technical assistance Individual owners: organization, collaboration and support for the component's management.

Forest management in protected natural areas

As a complement to the Forest Management Model, in 2014-2015 the Secretary of the Environment developed the first phase of the Map of Forest Management (MFM), which defines the different forest systems of the territory that should be promoted for the recovery and management of forest cover in the MDQ. This first phase was conducted in the following areas of the Metropolitan System of Protected Natural Areas (ACUS): Pachijal water and archaeological System; Mashpi, Guaycuyacu, Sahuangal and Yunguilla; AIER: Pichincha-Atacazo Axis; Wetlands Protection Area (APH): Mount Puntas; Ecological Corridor of the Andean Bear (CEOA). In addition, work has been performed in the territory on the Ilaló Lumbisi Special Intervention and Recovery Area (AIER) proposal.

The selection of these areas is based on their possession of management plans, their provision of general zoning (conservation, recovery and sustainable use), their development of participatory processes and their provision of regulatory support for municipal intervention (Ordinance 041).

With the application of the guidelines generated in the MFM it is intended to reduce the processes of the different levels of forest degradation (deforestation), restore degraded lands with appropriate soil conservation techniques and put them into productive service, manage water basins with the aim of maintaining the required quantity and quality of water resources, restore the rural landscape and initiate recovery of as many ecosystem benefits as possible, preserve biodiversity by maintaining connectivity of forest cover, improve levels of agroforestry, forest farming and forestry production, with better techniques and a greater range of possibilities for obtaining resources, restore and maintain environmental goods and services offered by the great biodiversity of tropical forests, and respect and preserve the values of communities and rural populations and benefit them with forest management adequate for their needs.

Forestry systems defined in the Map of Forest Management

Forest Management is based on the determination of homogeneous areas with similar physical and biotic characteristics, in which vocation and potential use criteria are integrated. Thus, four zones or systems were established, with one productive zone of little or no intervention. *Table 7* and *Map 4* detail the defined forest intervention systems.

Forest fires in the MDQ

The expansion of the agricultural frontier, exploitation of forests for logging, and urban sprawl have drastically reduced the extent of forests in the country. Additionally, there is increasing pressure on land use, which causes a reduction in water flows and a decrease in water reserves, which will cause problems in the availability of this resource for agricultural production, renewable energy and human consumption. Forest fires are one of the main causes of environmental damage.

Traditionally, fire has been used to change land use from forest land to land suitable for agriculture. While the slash and burn system at present has decreased, the use of fire in agriculture and livestock continues to be a factor of change in vegetation cover.

The periodic occurrence of forest fires is a change element in the natural conditions of the MDQ, and affects not only natural ecosystems, but also the adjacent ecosystems (forest plantations, agriculture, urban areas, transport networks, power lines, etc.), as well as society in general in different areas: human life and health, welfare, employment, economic and social activities, etc.

The natural scenery of the Metropolitan District of Quito is not free from the occurrence of forest fires affecting the integrity of its natural resources. The dry


Photo: Agencia Metropolitana de Noticias

Reforestation in the Puembo fire, MDQ Fire brigade

season of 2012 was an extreme period with a great quantity of fires and area burned that exceeded the capacity of control agencies. The Municipality of the MDQ had to declare an emergency in order to increase budgets, teams and interventions in the work of control and elimination.

In 2012, 1,037 fires affecting an area of 4,882.16 hectares were recorded; 743 correspond to the F1 fire category[2], with an affected area of 473.95 hectares; 203 fires were in category F2[3], affecting 884.90 hectares, and 91 fires were in the F3 category[4], with an affected area of 3559.13 hectares burned.

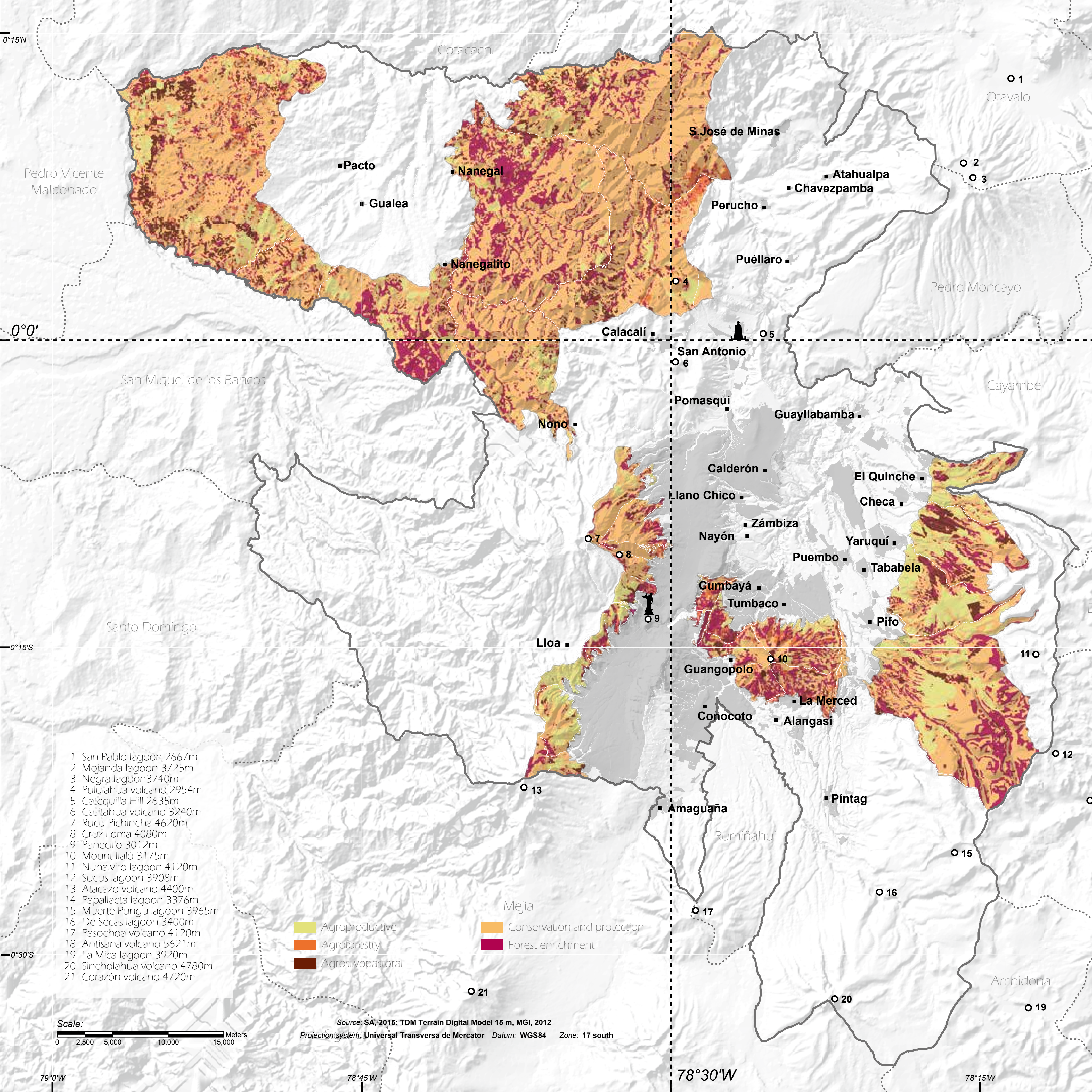
The most affected ecosystems were as follows: pastures 1128.10 ha, wet bushland 606.33 ha, dry bushland, rainforests 492.74 ha, wet grasslands 463.89, crops 439.03 ha, eucalyptus and other broadleaf plantations 420.89 ha, dry grasslands 267.78 ha, soil made bare due to anthropic activity 31.83 ha, dry forests 16.47 ha, pine and cypress plantations 12.57 ha, infrastructure 9.93 ha.

The economic impact of the damage, according to the methodology established by Resolution No. 1330 of the Ministry of the Environment, was US $26,744,472.48 in restoration costs, US $11,265,731.38 calculated for forest plantations, US $10,746,629.76 for loss of fixed carbon and US $733,265.00 dollars for loss of grasslands. A total of US $50,081,781.94 was lost.

Evaluation of the environmental and socioeconomic impacts of forest fires

It is said that there is environmental damage when an action or activity produces an unfavorable change in the environment or in some of its components. Barrantes (2002) states that, in general terms, environ-

2 F1: from 0 to 2 hectares
3 F2: from 2 to 10 hectares
4 F3: more than 10 hectares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Cotacachi
Otavalo
Pedro Vicente Maldonado
Pacto
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Puéllaro
Pedro Moncayo
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Calacalí
San Antonio
San Miguel de los Bancos
Cayambe
Pomasqui
Guayllabamba
Nono
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Tababela
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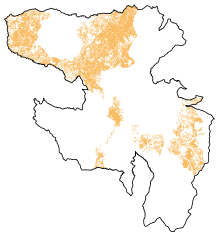
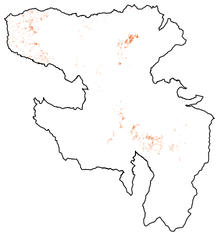
Guangopolo
La Merced
Conocoto
Alangasí
Amaguaña
Píntag
Rumiñahui
Mejía
Archidona
0°30'S
1 San Pablo lagoon 2667m
2 Mojanda lagoon 3725m
3 Negra lagoon3740m
4 Pululahua volcano 2954m
5 Catequilla Hill 2635m
6 Casitahua volcano 3240m
7 Rucu Pichincha 4620m
8 Cruz Loma 4080m
9 Panecillo 3012m
10 Mount Ilaló 3175m
11 Nunalviro lagoon 4120m
12 Sucus lagoon 3908m
13 Atacazo volcano 4400m
14 Papallacta lagoon 3376m
15 Muerte Pungu lagoon 3965m
16 De Secas lagoon 3400m
17 Pasochoa volcano 4120m
18 Antisana volcano 5621m
19 La Mica lagoon 3920m
20 Sincholahua volcano 4780m
21 Corazón volcano 4720m
Agroproductive
Agroforestry
Agrosilvopastoral
Conservation and protection
Forest enrichment
Scale:
0 2,500 5,000 10,000 15,000 Meters
Source: SA, 2015: TDM Terrain Digital Model 15 m, MGI, 2012
Projection system: Universal Transversa de Mercator Datum: WGS84 Zone: 17 south
79°0'W
78°45'W
78°30'W
78°15'W

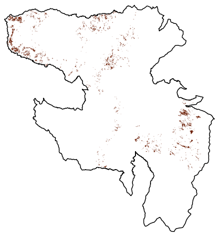
4 Map

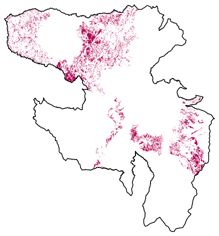
Forest Zoning in the MDQ intervention areas

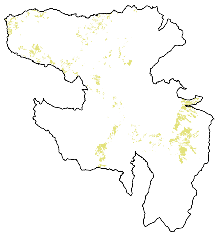
Table 7. Forest intervention systems



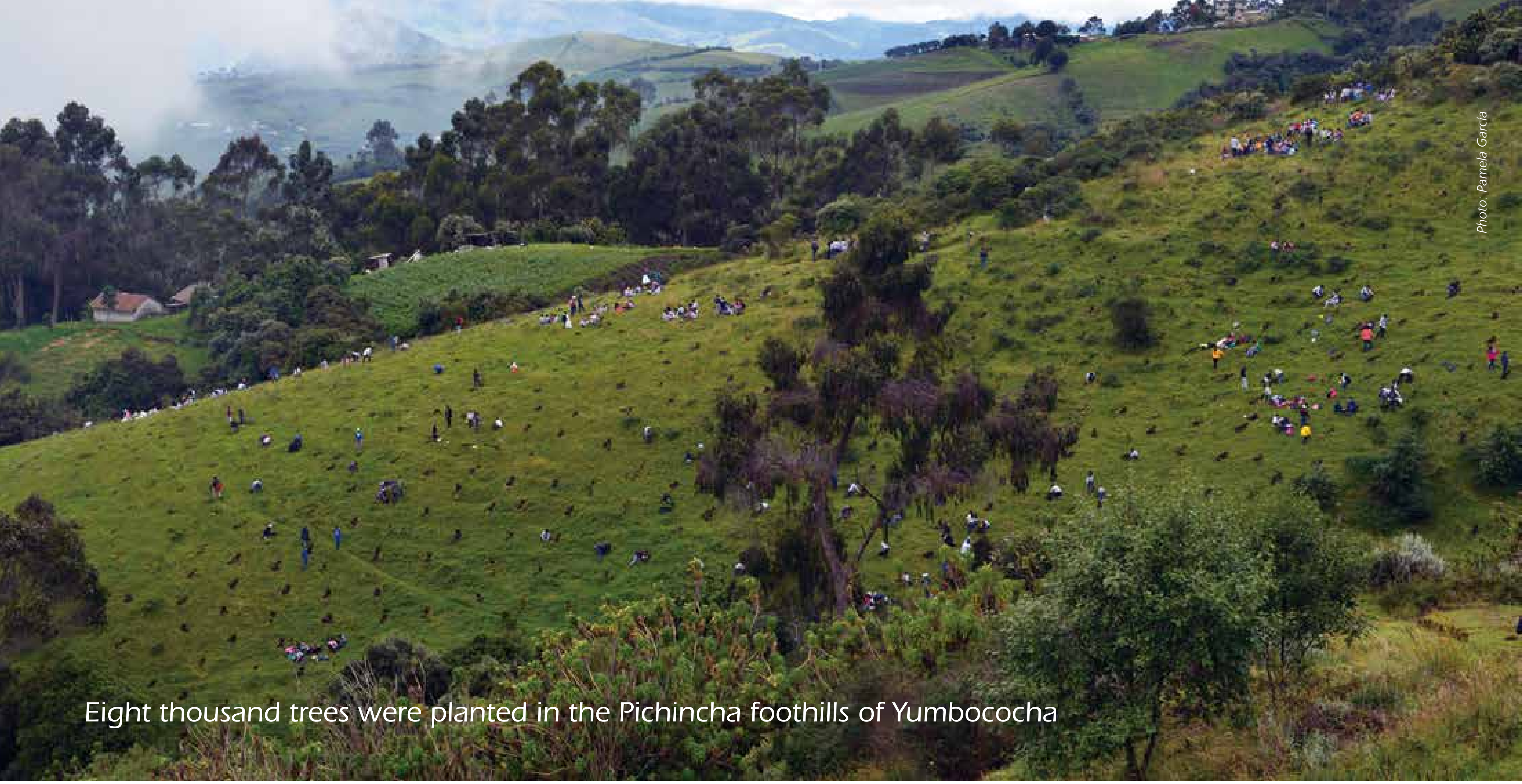








System	Description
Conservation system	Areas destined for the conservation of vegetation cover and the maintenance of the environmental services.
Agroforestry system	Areas where it is possible to produce crops along with trees plantations in a mixed space, as an alternative for improving production systems and preventing soil degradation.
Agro silvo pastoral system	Areas where it is possible to manage the livestock component together with the management of trees (legumes), improving animal concentration. This also contributes to restoring vegetation cover.
Enrichment system	Areas where it is viable to establish and manage forest plantations for conservation purposes (or for Non-Timber Forest Products) to recover vegetation in those places where it is deficient and/or allow the recovery of areas in different stages of forest soil degradation.
Consolidated productive crops	Areas where it is possible to establish agricultural systems of medium and large scale production, with investments in equipment



Eight thousand trees were planted in the Pichincha foothills of Yumbococha

mental damage represents the difference between the situation with and without the intervention, which requires knowledge of conditions before and after the environmental effect.

The economic assessment of environmental damage depends on two main components: the biophysical and social damage (Vera, 2004), biophysical damage refers to the damage to the natural environment that causes a deterioration of the characteristics of the natural resource. Social damage is related to the loss of benefits (goods and services) derived from the natural resources enjoyed by society.

The analysis of these two elements allows us to understand the magnitude of the environmental problem caused by forest fires and the need for their economic evaluation.

For the evaluation of the environmental and socioeconomic impact of forest fires, the Secretary of the Environment developed a methodology in 2012 addressing three key steps: 1) quantification of fires, 2) damage assessment, and 3) monetary valuation.

Forestation y reforestation in the MDQ

The Secretary of the Environment promotes the establishment of forest plantations for protection and conservation, based on specific technical and management tools, for the entire MDQ.

To achieve this, alliances and cooperation agreements are secured with key players linked with or interested in this subject in the MDQ, such as the private sector, the education sector, and organized groups of civil society, among others.

One of these key actors is the Fund for the Protection of Water (Fonag), with this actor interventions have been

Table 8. Forest species and altitude range

Altitude zone	Common name	Scientific name	Altitude range (masl)
3,001 - 4,000 masl	Yagual	*Polylepis racemosa*	3,600 - 3,800
	Yagual	*Polylepis sericea*	3,600 - 3,800
	Yagual	*Polylepis racemosa*	3,600 - 3,800
	Yagual	*Polylepis incana*	3,600 - 3,800
	Yagual	*Polylepis reticulata*	3,600 - 3,800
2,001 - 3,000 masl	Colle	*Buddleja coriacea*	2,800 - 3,900
	Pumamaqui	*Oreopanax sp.*	2,500 - 4,000
	Quishuar	*Buddleja incana*	2,500 - 2,800
	Porotón	*Erythrina edulis*	2,300 - 3,200
	Sacha capulí	*Vallea stipularis*	2,200 - 4,000
	Arrayán	*Myrcianthes rophaliodes*	2,100 - 3,300
	Laurel de cera	*Morella pubescens*	2,000 - 3,400
	Cedro	*Cedrela montana*	2,000 - 3,200
	Yalomán	*Delostoma integrifolium*	2,000 - 3,000
0 - 2,000 masl	Nogal	*Juglans neotropica*	1,900 - 2,500
	Cholán	*Tecoma stans*	1,600 - 2,900
	Tara	*Caesalpinia spinosa*	1,000 - 3,000
	Aliso	*Alnus acuminata*	900 - 3,500
	Molle	*Schinus molle*	0 - 3,000
	Faique	*Acacia macracantha*	0 - 2,000

made at strategic sites in the MDQ. Between 2009 and 2013 interventions covering approximately 2,585 ha were made as a result of the partnership between Fonag and the Secretary of the Environment.

Additionally, in the period 2010-2012 with the implementation of the Areas Affected by Forest Fires Recovery Plan (AAFFRP) it was possible to plant a total of 416,148 trees covering an area of approximately 500 ha. The Zonal Administrations participated in this plan, under different modalities of intervention and financing: forestation contracts, workshops with local populations and students, and projects funded by the Environmental Fund or by the Secretary of the Environment's budget.

Between 2013 and 2015, 920,160 trees were planted in an area of approximately 1,000 ha. During 2016, up to the month of April a total of 66,638 trees covering an area of 76.25 ha were planted.

In summary, it is estimated that from 2009 to 2016, the Secretary of the Environment intervened in approximately 4,161.25 ha, located in strategic and priority sites within the MDQ.

Importantly, the Secretary of the Environment created a registration system of forest plantations in order to monitor the recovery process of vegetation cover. In addition to the records, the reforestation sites have also been logged using georeferencing.

Table 8 shows the altitudinal ranges and the main species used in these processes for the recovery of vegetation cover.

Moreover, concerning forest plantations of rapidly growing exotic species, the Novopan company of Ecuador has more than 3,600 ha of *Pinus radiato* and *Eucaliptus sp*, distributed in different projects belonging to the organization: Itulcachi, San José, Tulugchi, Barrancas, New Aurora and Corrales, as well as others established in the form of agreements, one of these is with INIAP in south Quito. Novopan fully utilizes raw material from the management of private plantations (pruning and thinning) and byproducts from the timber industry.

According to the vegetation map for the MDQ (2013), 7,743 ha are within the category of cultivated vegetation: broadleaf, including eucalyptus plantations in adulthood and regrowth, which are located in the peripheral area of Quito and the valleys, predominantly on the slopes of Pichincha, and 1,524 ha such as cultivated vegetation of coniferous: pine and cypress.

The Urban Green Network

The Urban Green Network (UGN) program was born with the aim of systemically integrating the components of the natural environment surrounding and within the city, to recognize or grant functions under the sustainable city concept.

The Urban Green Network was initially conceptualized as a system of connectors of vegetation through the urban fabric, creating a spatial link between natural conservation areas and green spaces with ecological value, facilitating mobility and providing habitat for urban wildlife.

However, the Urban Green Network goes beyond mere environmental contributions, since it will allow the construction of new patterns of behavior concerning the relationship between nature and the city from the perspective of the sustainable development of the Metropolitan District of Quito, through reinforcement of the economic, social and heritage values that will contribute to improving livability in public spaces, health and environmental quality, social cohesion, cultural integration and equity, universal accessibility, and the assessment and re-enhancement of natural heritage and of symbolic spaces for citizens.

The Urban Green Network seeks to fulfill three key roles in the city: the strengthening and recovery of urban ecosystems, habitability in public spaces, and placing value on the natural landscape and cultural heritage. To this end three categories are defined: Ecological UGN, the Revitalization of the UGN and the Natural Landscape and Cultural Heritage UGN, which interrelate within the territory (*Infographics 6 and 7*).

The Ecological Urban Green Network proposes to consolidate an urban-ecological model for recovery and strengthening of urban ecosystems, which are the natural systems that persist in urban areas or their surroundings. The importance lies in the ecosystem services that these systems provide for the common good and in ensuring resources for future generations are a priority.

Ecological UGN intends to restore natural habitats to protect species endangered by the urbanization process, mitigate the effects of deforestation and soil sealing, place value on the ravine streams and natural sources of water resources, recover biomass in urban areas and, broadly, generate sustainable urbanism.

The urban-ecological model consists of relating and interspersing urban spaces with natural areas using ecological and landscape tools. This relationship will permit articulation of the natural wealth of the MDQ with the urban fabric, also creating a perception of bridging the urban area of Quito through the connection of forests in the eastern and western sides of the city (Green Belt), and will connect ecosystems of high ecological importance, now isolated and fragmented by the growth of urban sprawl.

In this way the movement of wildlife, especially birds, is facilitated, to allow genetic exchange processes between small and isolated populations and increase or regenerate the original biodiversity[5].

For this purpose, five green corridors in the urban area of Quito were designed, covering an estimated area of 35 km and aiming to connect relicts of forests found on the east and west sides of the city.

Urban Green Network Revitalization is understood as a strategy to re-activate and re-boost public spaces, especially after a period of deterioration, inactivity or stagnation. It proposes the challenge of generating habitability in public spaces to encourage their use by the public. Strategies emerge from the real understanding of the meaning of vegetation in

5 In the Urban Sustainability Indicators Plan, by Vitoria-Gasteiz, the author notes that the assessment of the abundance of bird species in urban areas is an indicator of urban biodiversity, which evidences the state of conservation and the management of urban green areas.

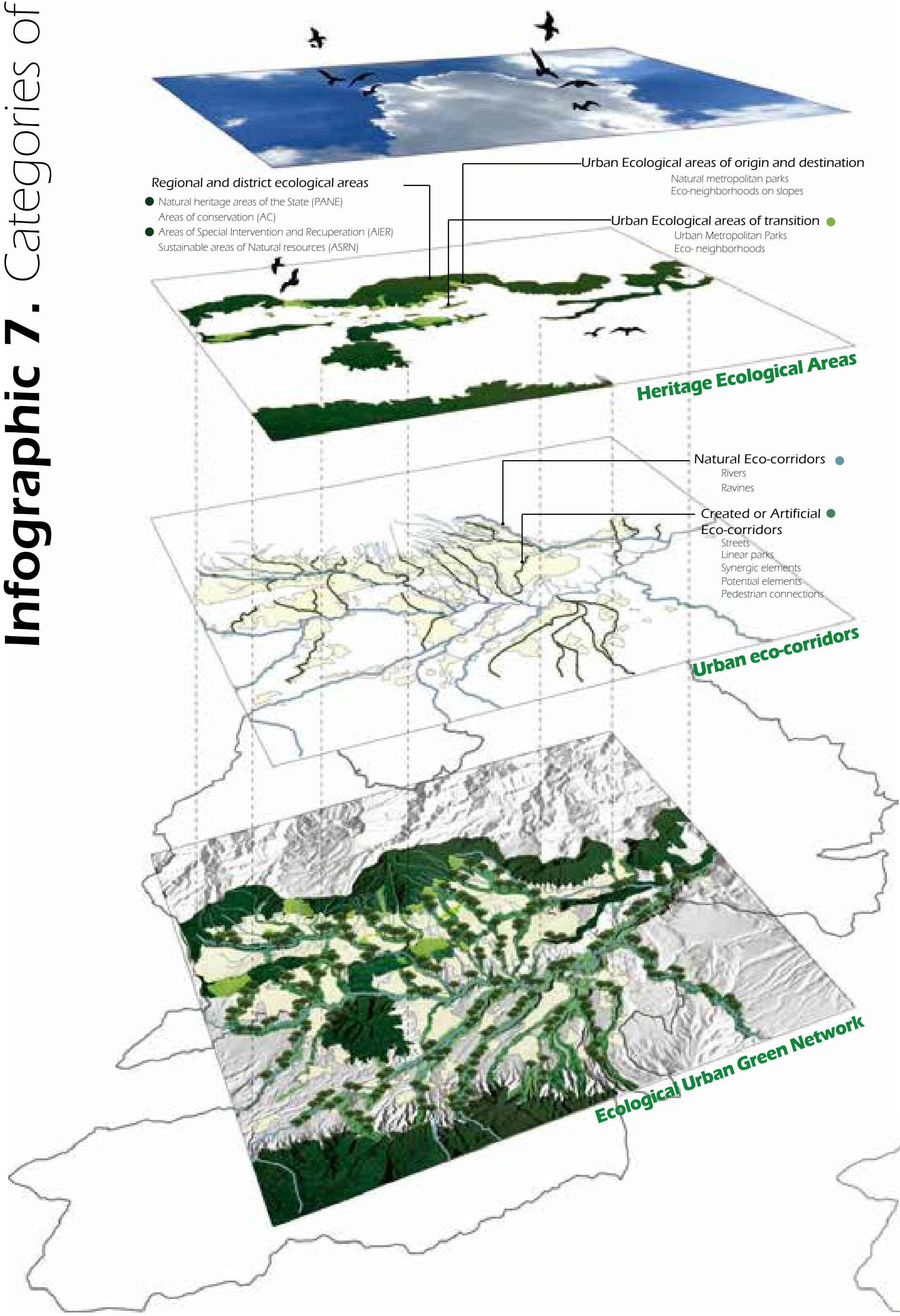
Infographic 6. Urban Green Network

Source: STHV- DMDU

Infographic 7. Categories of the UGN

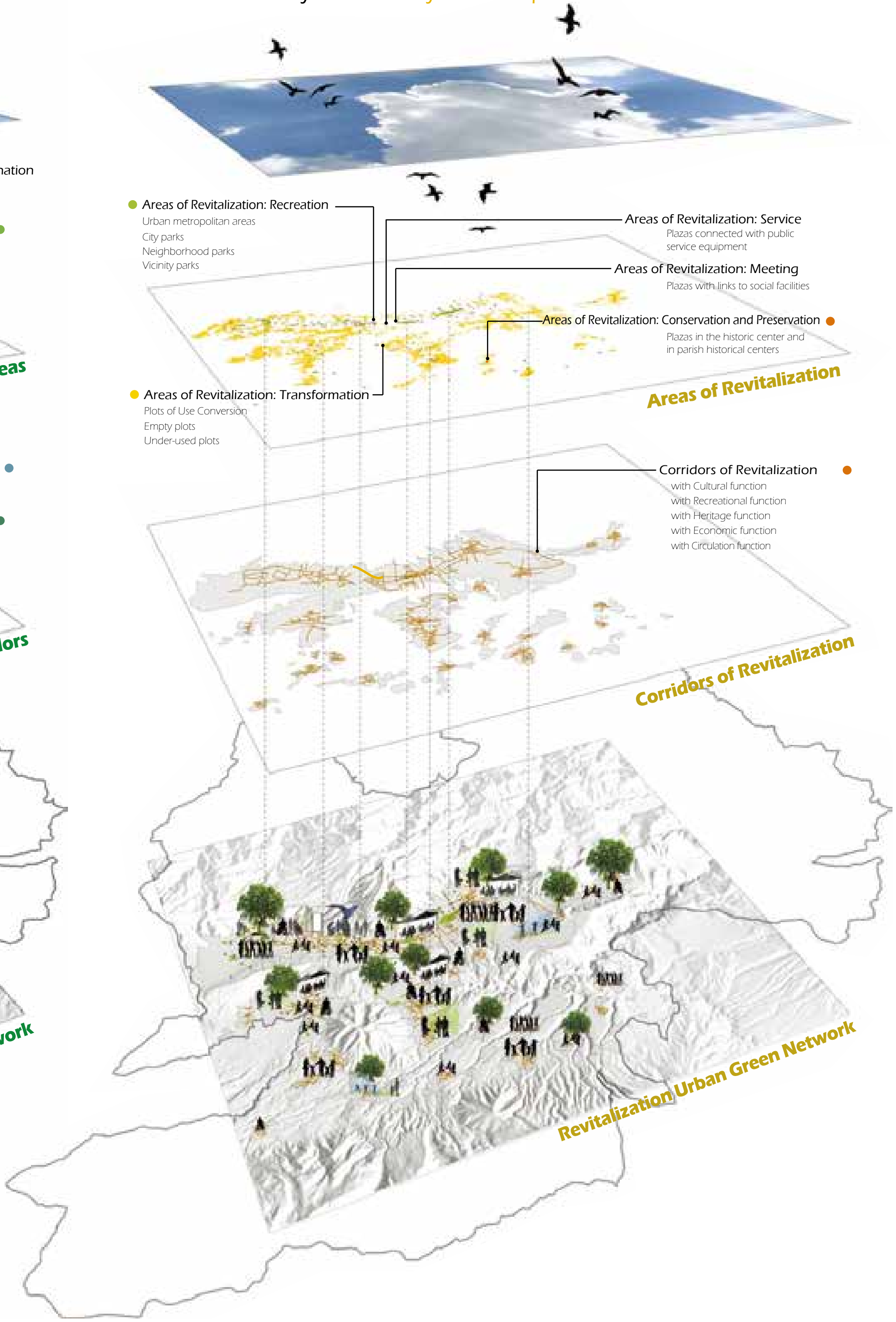
Ecological UGN

Role in the city: Strengthening and recovering of urban ecosystems



Revitalization of UGN

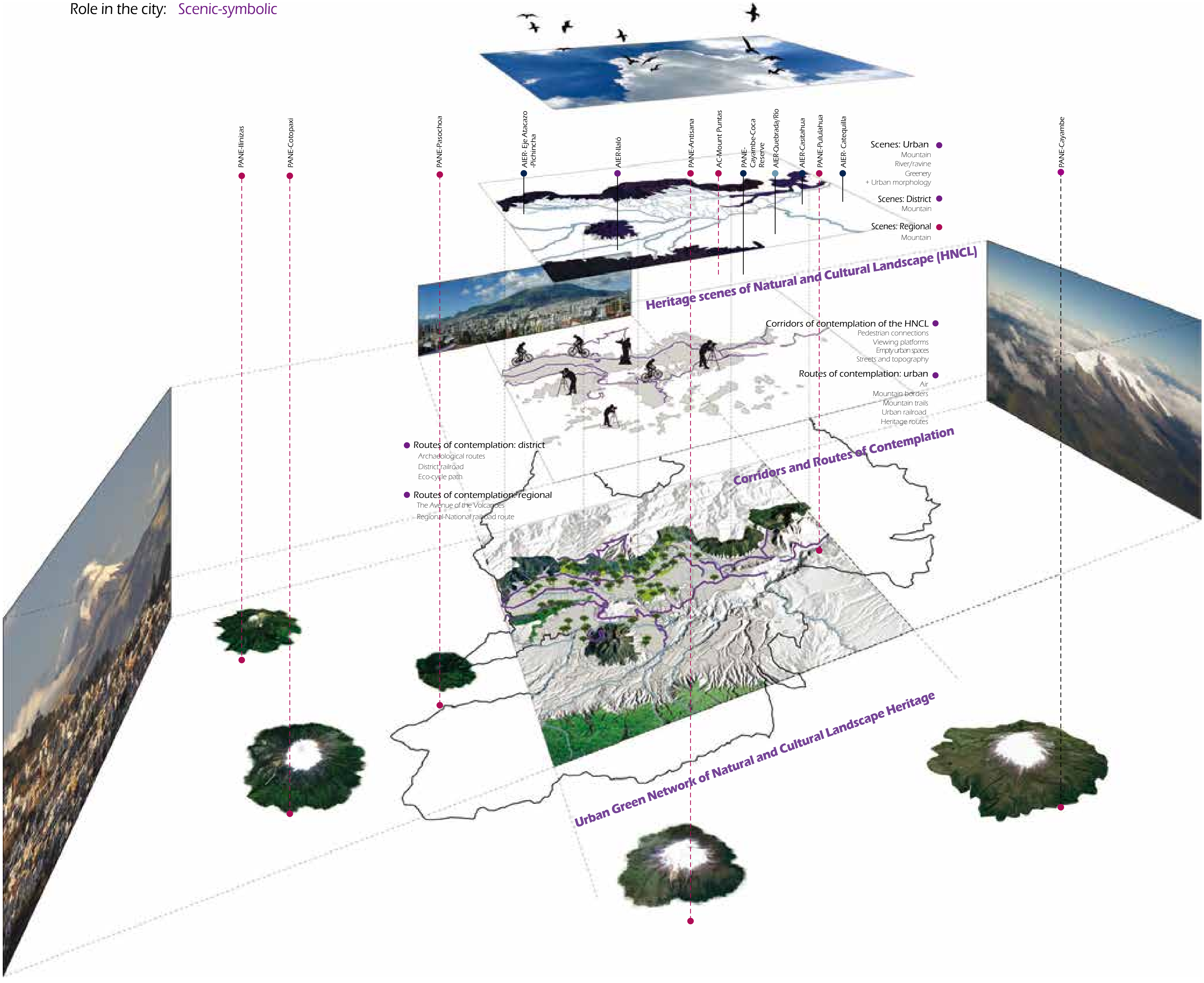
Role of the city: Habitability in Public Spaces



Source: Secretary of the Territory, Habitat and Housing of the Municipality of the Metropolitan District of Quito. 2014. Towards a sustainable model of the city: Urban Green Network and eco-neighborhoods. Quito, Ecuador

UGN of Natural Landscape and Cultural Heritage

Role in the city: Scenic-symbolic



Infographic 8. Public spaces

the city, associated with its environmental, social, economic, cultural and heritage values, and their interrelationship in public spaces (*Infographic 8*).

Public space, or the house of everyone, is understood as the physical air, surface or underground space with open access which constitutes the scene of daily social interaction and in the context of which citizens exercise their rights in the city. In this space urban, architectural, landscape and natural elements are incorporated, allowing the relationship and integration of the areas and facilities of the Metropolitan District of Quito.

Public and private actors are involved in boosting the habitability of public spaces; public assets being for public use and private assets being either for public use or linked to public assets to generate visual, environmental and other impacts, and all existing natural or constructed elements are deployed or installed in the assets destined for public use[6].

The Urban Green Network of Natural Landscape and Cultural Heritage proposes to enhance and place value on natural and landscape heritage, understanding the Metropolitan District of Quito to be a unique territory in which mountains, ravines, rivers and vegetation coexist.

It also proposes a reflection of the transformation of 'natural landscape' due to urban historical processes as part of the identity and heritage of the city, the result of this transformation is called the 'cultural landscape'.

6 In the Urban Sustainability Indicators Plan, Vitoria-Gasteiz noted that to assess the quality of habitability in public spaces three groups of variables that influence the positive perception of public space should be considered: ergonomic, physiological and psychological.

The Network allows identification of corridors or routes of contemplation that will enhance the heritage value of the natural and cultural landscape. Unlike the other categories, this network transcends towards visual connection with the compositional elements of the landscape, for the assessment of natural scenes surrounding the district.

The Urban Neighborhood Green Index (UNGI)

Understanding the benefits provided by ecosystems, the World Health Organization (WHO) has established a minimum of green space per inhabitant, which ranges from 9 to 14 square meters per inhabitant (9 meters is considered as an acceptable minimum and 14 as ideal). This standard notes that the municipality or the state should direct its future management towards meeting the demand for green spaces. In 2012 the Municipality of the MDQ considered it necessary to have more detailed information regarding the distribution of these green areas to establish a UNGI for the consolidated urban area, for the parishes within it, and for each neighborhood of the MDQ.

The study on the *Urban Green Network Baseline* performed by the Secretary of the Environment, from November 2012 to March 2013, analyzes the UNGI for the Zonal Administrations (ZA) that have territory in the urban center, using layers from the Use and Operation of Soil Plan 2013. Green areas included in the analysis were those greater than 2,500 m^2, in this manner obtaining a filter for the exclusion of areas such as flower beds and traffic circles.

To calculate this Index the information for total urban green area was attained and divided by the total population of the parish or the urban ZA. This figure (ratio) is inaccurate as it only considers figures for the surface of ‘urban green areas’ and the population by parish within each Zonal Administration, but does not include an analysis of criteria such as the amount of vegetation present, soil permeability, or accessibility, among other factors.

This calculation was made using information from the INEC National 2010 Census, meaning that the up to date figure will have changed significantly.

In calculating the UNGI care must be taken to exclude areas that do not contain significant vegetation, such as cemented playing surfaces or courts made of compacted earth and without vegetation. Therefore, a comprehensive and detailed filter is required to accurately identify only green areas with permeable soil and vegetation, and therefore with ecological functionality. On the other hand, although roadside trees and flowerbeds have functions that benefit the environment in general, the capacity for citizens’ enjoyment of these should also be it taken into account. Therefore, public woodland and private gardens are not considered when calculating the UNGI.

In addition to these considerations, to calculate the UNGI it is essential to determine the accessibility of each of the urban green areas (which include urban parks for public use, spaces where vegetation cover is prioritized over buildings, and public gardens). Accessibility considers the direct area of influence of each urban green space, internationally a distance of 300 meters around the site is accepted as having access to the green area, meaning that every green area, according to accessibility, provides service to citizens within this radius.

Urban Woodland

In the knowledge that these trees are destined to survive in the urban environment and we expect to receive a significant amount of benefits of all kinds from them, they cannot be managed by following ordinary forest guidelines. In 2014 arboriculture was introduced to municipal management, a specific science for the technical mediation between trees and the city.

Following arboriculture guidelines, new management parameters for the district's urban woodland were established, training activities were developed for workers of the Unit of Public Spaces in new plantations, with respect to pruning systems, procedures for punishing offenders against trees were designed and established, in coordination with the Metropolitan Control Agency, Resolution SA-PN-2016-001 was emitted to protect urban trees, and new technical manuals that update and correct management criteria were issued.

All planting effort, however small, can be an effective contribution to the Urban Green Network. Obviously the ideal situation is that efforts should be technically targeted so that results are effective in the medium and long term.

For these reasons urban woodland must be protected and technically managed so that we can take advantage of and enjoy the many benefits that this brings.

Heritage trees

For urban woodland there is a special management program focused on the most important tree specimens of the district, heritage trees.

These trees stand out due to one or several biological, scenic, historical, cultural or social characteristics, and after fulfillment of the corresponding procedure are declared as heritage trees and therefore cataloged.

Compliance with one or more of the above characteristics allows specimens to form part of the heritage of the city, which means protection, recognition and conservation. The heritage declaration means that these trees cannot be cut down, damaged, mutilated, or destroyed, thus altering their state or aspect, unless there is an imminent danger to persons or property, a situation which must be duly and swiftly analyzed by the corresponding municipal, environmental and technical authorities.

Although the management of heritage trees began as a private initiative from the Botanical Garden of Quito, through Resolution C 433 it became a direct competence of the Municipality, and the bodies responsible for the maintenance, upgrading and formalization of the technical criteria and cadastre were assigned. On the basis of the above mentioned Resolution, 303 trees were declared as heritage.

In May 2015, during the celebration of Arbor Day, the Secretary of the Environment, through Resolution No. SA-PN-001-2015, declared 51 new specimens as Heritage of the City and presented the book Quito's Heritage Trees to the city.

Protection of water sources in the MDQ

The Fund for Water Protection (Fonag) is the institution responsible for implementing actions for the protection of water sources for the MDQ. Fonag's mission is "to facilitate, in partnership with local institutions and actors, protection of the watersheds that supply water to the Metropolitan District of Quito, through a financial mechanism that implements programs and conservation projects, ecological restoration and environmental education, for a new water culture and integrated management of water resources."

This entity's projects are aimed at the protection of ecosystems found in the river basins that supply wa-

ter to the MDQ, such as the basins of the Pita River and the San Pedro River, the micro watersheds in the eastern mountains that feed the potable water systems of La Mica and Papallacta, and the micro watersheds on the Pichincha-Atacazo axis.

Fonag's scope consists of areas of paramo moors and high Andean forests with different states of conservation and realities regarding tenure and land use. This means working with the different ecosystems that currently capture 75% of the water consumed by the city of Quito. In addition, according to EPMAPS planning, the scope of this work will be extended to include actions for the identification of new projects for water catchment systems.

Fonag implements several key thematic programs to ensure the protection of water sources in the MDQ. The 'Communication Program' promotes a water culture and tries to achieve the vision of co-responsibility between the different areas that are directly involved in the care of water sources.

The 'Vegetation Cover Recovery Program', through restoration projects and forest plantations, aims to protect the watersheds that supply water to the Metropolitan District of Quito. This area is currently under severe pressure because of demands for water for irrigation and urban expansion. Research processes of this program have obtained results concerning the quantity and quality of water that can be generated thanks to restoration actions in degraded areas. Significantly, under this program, Fonag's projects plan measures for the involvement of and compensation to local communities

Photo: Alex Hirtz

Pinus radiata surrounded by *Platanus acerifolia*. Heritage trees in El Ejido park.

with promotion and advice for the generation of sustainable productive activities. To date, 7,880 ha have been recovered.

The 'Water Guardians' environmental education program makes field visits and holds workshops with children and young people so that, through pedagogical mediation, a new awareness of the protection of the sources and uses of water is generated. In this program work is performed with students from the provinces of Pichincha and Napo. Among the topics covered are: river pollution, the importance of ecosystems, native species, recycling, water quality and other issues that affect the care of nature and water. Since 2005, about 35 thousand people have been sensitized in water care.

In the Water Management Program, the goal is to establish an integrated management of water resources in the upper basin of the Guayllabamba River and its areas of direct influence. To support the decision-making of users and stakeholders in the basin and contribute to integrated planning, studies and technical tools based on data collection, information processing, modeling and technical analysis are needed. This basin's information and monitoring system is important to evaluate the availability of water and the evolution of the impacts associated with this resource. In parallel, this creates information for the design of strategies for adaptation to climate change when evaluating the impact of this phenomenon on the vulnerability of the population and on water management processes.

Another component of this project refers to gathering information from water users in the upper basin of Guayllabamba, this information will allow the rationalization of resource use, reducing conflicts that may arise from its utilization. The spatial modeling component permits adequate management and protection of vegetation within the area and the identification of priority intervention areas for care and upkeep.

Climate change is also of interest when establishing the vulnerability of communities. Fonag began collecting data in different areas to find out their potential exposure to climate threats, levels of sensitivity and adaptability. The results of regional models in the current and future analysis of local climate variability will enable the proposal of lines of sustainable intervention, in the short and long term, to increase capacities for adaptation in the most vulnerable communities and at the same time to protect the sources of water in the basin. This work requires the active participation of national and local organizations. For this reason local communities are trained in issues of climate change vulnerability.

In the Areas of Sustainable Water Conservation Program, the main action is the 'control and monitoring' of areas protected due to interest in water resources. To achieve this, the project can count on the participation of 15 moor rangers in the Antisana Ecological Reserve, the Cayambe-Coca National Park and the Cotopaxi National Park for surveillance of the moors and monitoring of fauna and flora. From just two properties of EPMAPS around 15,000 hectares are protected. As part of the establishment conservation agreements, the program also works with rural and indigenous communities in identifying environmental problems and applying sustainable practices that contribute to community development.

Management policies to address climate change

To guarantee the local sustainability of the territory focused on the reduction of and compensation for the carbon footprint and the resiliency of the MDQ to climate change.

The Metropolitan District of Quito has defined goals that plot the path towards low-carbon development and resilience to climate change, has designed the tools necessary to monitor achievement of the goals and has promoted the active participation of citizens.

Recently, the MDQ's Secretary of the Environment has assessed the performance of the city, and calculated and generated a series of indicators such as 'carbon footprint', 'water footprint', 'ecological footprint', and 'GHG emissions inventory', which constitute the main tools guiding environmental and climate change management in the Metropolitan District of Quito.

This approach, using the indicators listed above, welcomes the conceptual vision of 'Quito, sustainable city' and is aligned with the proposal of joint work of the Municipality with citizens and with public and private companies and institutions, with the mission of reducing the footprint on nature and increasing resilience in order to respond to the effects of climate change.

The political and regulatory framework at the level of the Metropolitan District has evolved together with a process of institutional transformation. Since 1992, regulations and legislation to facilitate territorial and environmental management have been generated (*Table 9*).

Figure 9 shows the objectives and main strategic lines of action related to climate change.

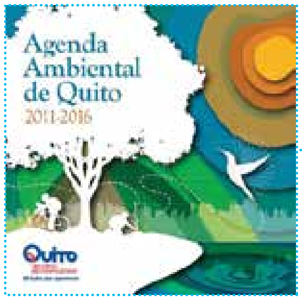
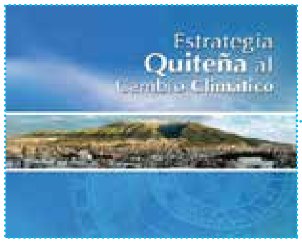
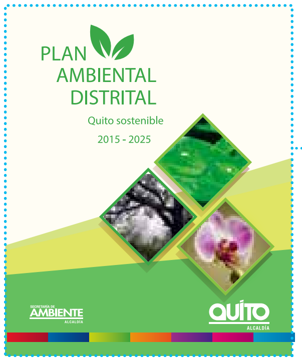
Compact of Mayors, Quito

The Metropolitan District of Quito obtained certification of full compliance with the Compact of Mayors in December 2015, during COP 21, after verification of its progress on climate change, such as the carbon footprint inventory, the district vulnerability analysis, the Climate Action Plan, and local climate change policies and targets.

The Compact of Mayors has the objective of calling cities and regions of the world to climate action to reduce emissions of greenhouse gases in their territories, improve resilience to climate change and check progress in a transparent manner.

The Climate Action Plan of Quito is the local roadmap for the management of climate change, which integrates a set of goals and prioritized adaptation and mitigation projects, with the implementation of appropriate, transversal and equitable measures that reduce the climate footprint, within the framework of broad citizen participation.

Table 9. Local policies and regulations for the management of climate change in the MDQ

	**Metropolitan Development and Territorial Management Plan (2015-2025)**	Gathers instruments that define strategies contributing to the mitigation for and adaptation to climate change
	**Environment Agenda 2001-2006**	This is a socio-political instrument of strategic guidelines that guide environmental management. It comes from a participatory process (250 representatives from civil society and the public and private sectors) that sought to bring together and mobilize the key actors of Quitenian society along four main axes: "We care for and sustainably manage the MDQ's natural wealth" "We are ready for and we can respond effectively to climate change" "We produce and consume with environmental and social responsibility" "We actively participate in the construction of a green and clean Quito"
	**Quitenian strategy for Climate Change (EQCC) 2010-2015**	In 2009 the Metropolitan District of Quito approved the Quitenian Strategy for climate change (EQCC) as the first response of an Ecuadorian local government to the challenges of climate change.
	**Quito's Plan of Climate Action 2012-2016**	The EQCC is implemented on an inter-sectoral basis through Quito's Plan of Climate Action 2012-2016, which establishes integrated policies that seek to ensure the adoption of adequate, transversal and equitable measures for adaptation to and mitigation of climate change, and to create appropriate management methodologies and instruments for investigation and timely information within the framework of a wide and permanent participation of actors and decision-makers in the MDQ.
	**Plan of Climate Action District Environment Plan (PAD) 2015-2025**	The District Environment Plan aligns the existing environmental policies with the programming of the relevant axes for environmental management in the MDQ, and provides the inputs necessary to achieve integrated environmental management with the involvement of citizens and the participation of organizations and institutions, through thematic plans among which the Plan of Climate Action is included.

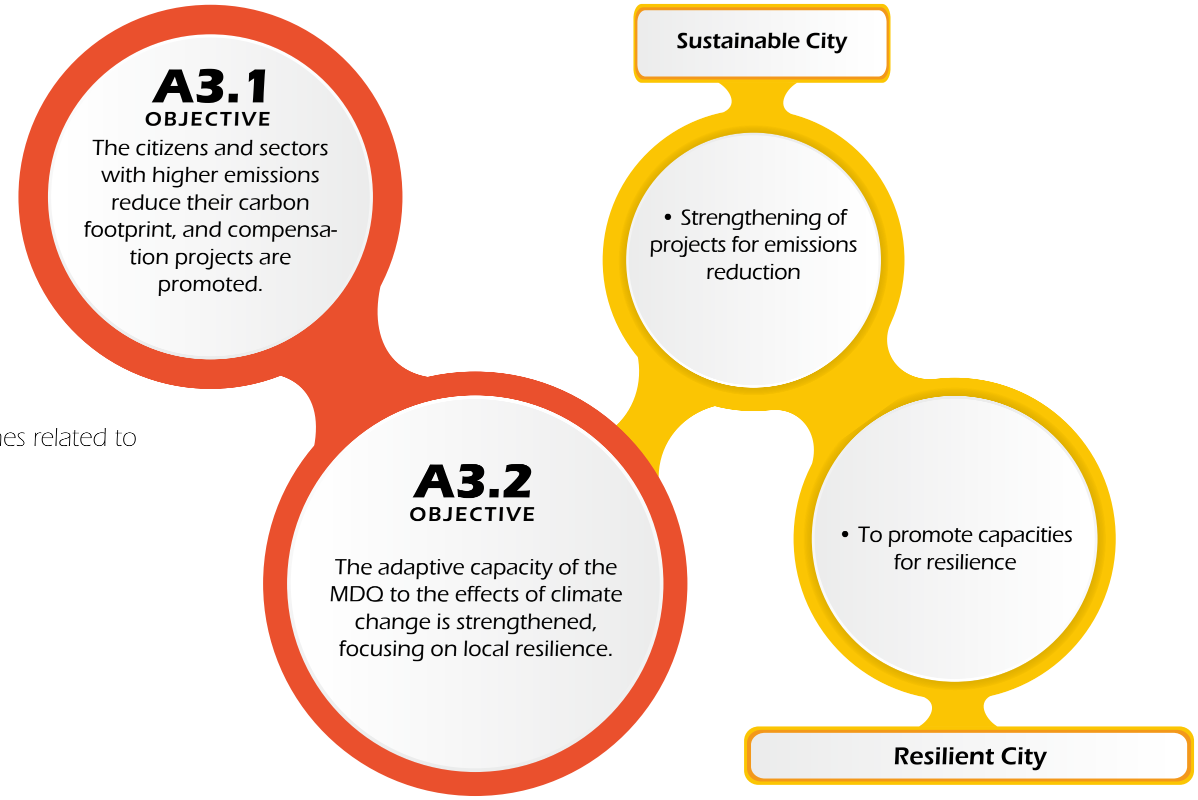


Figure 9. Strategic lines related to climate change

Management of climate change

For the management of climate change the goal of a 5% annual reduction of the carbon footprint of the MDQ relative to projected growth from 2019 has been proposed. To achieve this, work focuses on the area of mitigation, which according to the Intergovernmental Panel on Climate Change (IPCC), is the anthropogenic intervention to reduce sources or improve carbon sinks.

Priority sectors for mitigation are sustainable mobility, sustainable construction, public services of the MDQ and compensation for carbon footprint (*Infographic 9*).

Sustainable mobility

About 4,3 million trips are generated daily in the MDQ, of which two thirds are made by public transport; journeys are distributed in the different modes of transport (*Infographic 10*).

30% of trips are made in mass integrated transport, a percentage that grew to 40% in 2013. In that same year 895,378 trips per day were made in private cars and 217,206 in taxis (Secretary of Mobility, 2013), with a load factor estimated at 1.6 people per car.

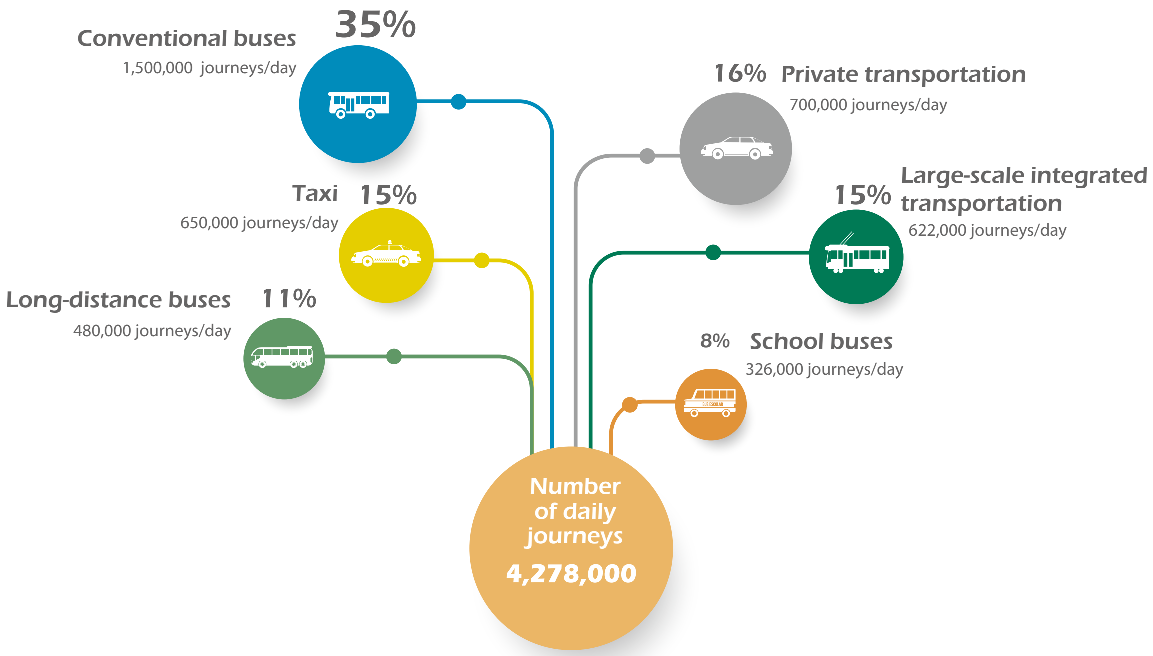
Figure 10 shows the estimated number of trips made along each line of the Quito Metrobus, in conventional public transport, private cars and taxis. Projections are made until the year 2025, with the assumption of an annual growth rate in the number of public transport trips of 1.5% and 2.5% using private transport.

This represents an important opportunity to adequately plan mobility strategies and policies with sustainable programs and projects.

To meet this challenge of moving towards a model of sustainable mobility in the MDQ, the Municipality created the Mobility Master Plan, which, after a comprehensive description of the context and the expected development of the MDQ's transport sector, outlines the main strategic actions to be implemented during the period 2009-2025.

Infographic 9. Sectors that reduce the carbon footprint in Quito

Infographic 10. Daily journeys using the different modes of transport in the MDQ 2011.



Source: Study for the conceptual design of the integrated large-scale transportation system in Quito and the feasibility of the first underground metro line in Quito.

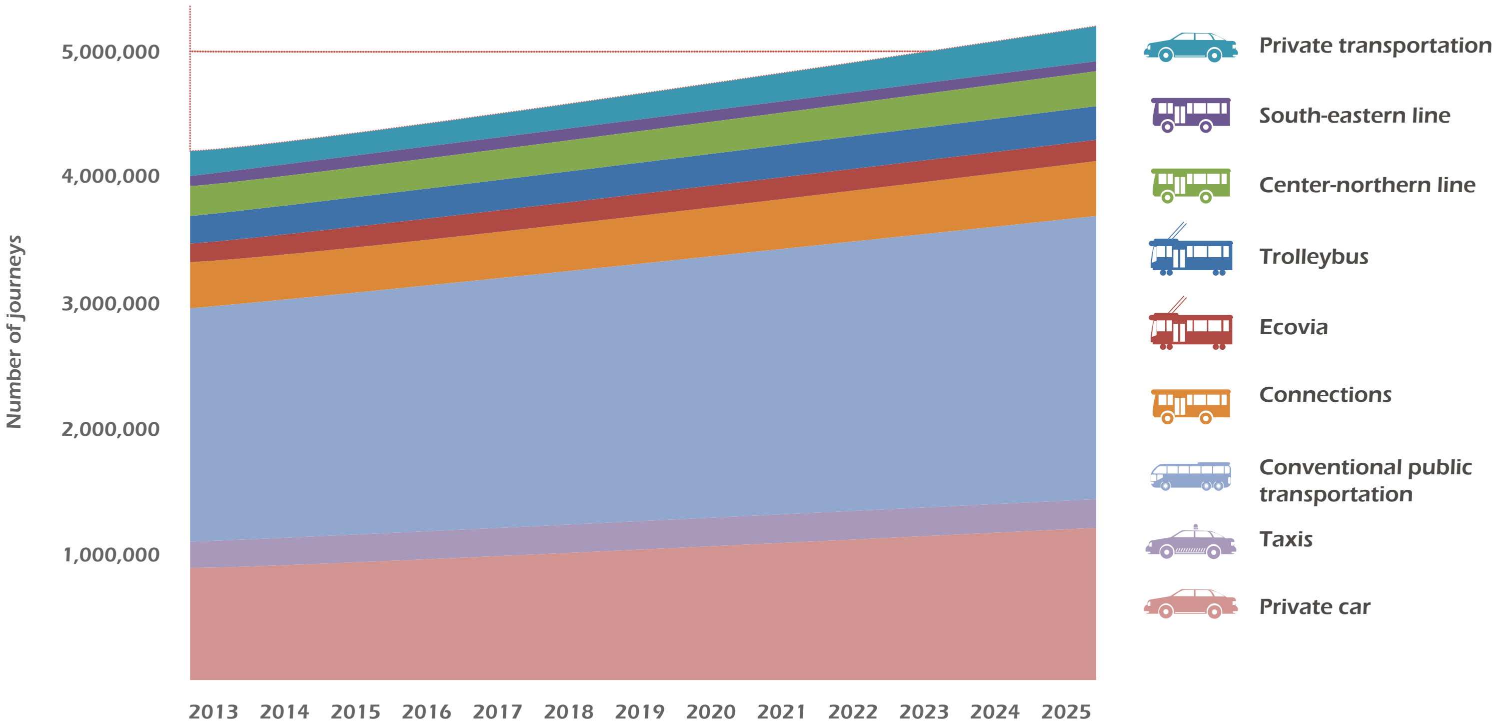


Figure 10. Estimate of journeys with the current scenario

Quito seeks to be a fluid city with a sustainable mobility system, which includes projects such as the first line of the Metro subway, the northern extension of the Trolleybus System, the Quito Cable Car System, encouraging the use of modes of non-motorized transport and giving priority to pedestrians, cyclists and public transport users.

Improving the Integrated Public Transport System, traffic management and promotion of alternative means of transport have the potential to reduce the carbon footprint by 100,000 tons/year, improve air quality in the MDQ, and reduce the ecological footprint of Quito.

Sustainable construction

Current and future environmental and climatic conditions require the incorporation of sustainability criteria in territorial planning, urban development and construction on different scales: country, city, neighborhoods, housing complexes and buildings. This involves acting at different levels: creating a political and legal framework to determine objectives, goals and basic parameters, which should be reflected in the rules and instruments of territorial management and adequate construction, and performing discursive and didactic work to create awareness of citizens, owners, builders and real estate agents.

At the district level, limiting the growth of the urbanized area, and the controlled consolidation and densification of urban land emerge as basic elements of sustainable territorial development (MMDQ, 2011). This is complemented by the implementation of measures at the level of equipment and housing, among which the following are highlighted: efficient and autonomous energy consumption, responsible consumption of drinking water, recirculation and potential treatment of gray water for secondary uses, storage and reuse of rainwater for the maintenance of green and communal areas, the definition of construction coefficients for limiting soil sealing, sorting and recycling of waste, and design criteria focused on the use of light, temperature maintenance and adequate ventilation, all forming part of the new vision of habitability in the context of climate change.

Through this line of action the municipality is seeking to develop institutional tools to strengthen municipal territorial management, such as the generation of rules for sustainable construction, which will be attached to the reform of Municipal Ordinance No. 172, in the Urbanism Technical Regulations, to promote and encourage citizens to implement new standards of sustainable construction.

MDQ Public Services

Regarding public services, the challenges assumed by the Municipality include solid waste management, the decontamination of waters in the rivers of Quito, and management of efficient lighting, programs that have a high potential for reducing the carbon footprint of the city.

- The Decontamination of the Rivers of Quito Program has an impact at regional level (in cantons Quito, Rumiñahui and Mejía) in the areas of sanitation and electricity generation, and will not only treat the wastewater of 99% of the population living in this region, but will also create a potential reduction of 148,271.46 tCO_2e per year and reduce the water footprint of the city by 85%.
- Solid waste management, in its various stages, has great potential for GHG reduction. The use of biogas from landfill sites for the production of 5 MW of electricity represents a reduction of 100,000 tons of CO_2e per year in the carbon footprint.
- Streetlights consume 188 GWh-year of electricity generating 36,000 tons of CO_2e. Al-

though its contribution in magnitude to the footprint of the city can be seen as marginal (about 1%), this is equivalent to the electricity consumption of approximately 100,000 Quitenian households in a year.

- During 2013, in the historic center of Quito nearly 2,000 luminaires was replaced by efficient LED lighting systems, at a cost of close to 2 million dollars, representing the elimination of the equivalent of 400 tons of CO_2 per year. As such, the total replacement of luminaries could mean reducing by half the contribution made by public lighting to Quito's carbon footprint.

Compensation and Carbon Footprint

According to the map of vegetation cover in the MDQ (2011), natural heritage covers an area of 256,407 ha, corresponding to 60.46% of the district's total surface area, including a quantified 118,000 hectares of distinct types of forest, and taking as a reference the carbon content indicators of the current National Forest Assessment, there is a stock of 10.4 million tons of carbon in these forests (*Map 5*).

The expansion of urban sprawl and the dynamics of land use and occupation generate a constant demand for goods and services, making it a priority to create mechanisms of intervention in ecosystems in order to increase their potential level of resilience, reduce GHG emissions and contribute to the welfare of people who live and depend on natural heritage, involving civil society and the private sector.

Given this context, and considering that the challenges presented have a direct impact on the health of the population and the competitiveness of the MDQ, the design and implementation of a compensation mechanism for the carbon footprint of companies and private institutions of the MDQ has been promoted.

The Carbon Footprint Compensation Mechanism (emissions of greenhouse gases), aims to implement local sustainability actions with potential to reduce the carbon footprint, to be financed with resources from actors in the territory who are interested in offsetting the emissions that they cannot feasibly reduce, and within the framework of their sustainability policies that provide for the management and measurement of their carbon footprint, linked to the environmental and productive development policies of the district, to promote the Metropolitan District of Quito as a socially responsible territory.

Adaptation

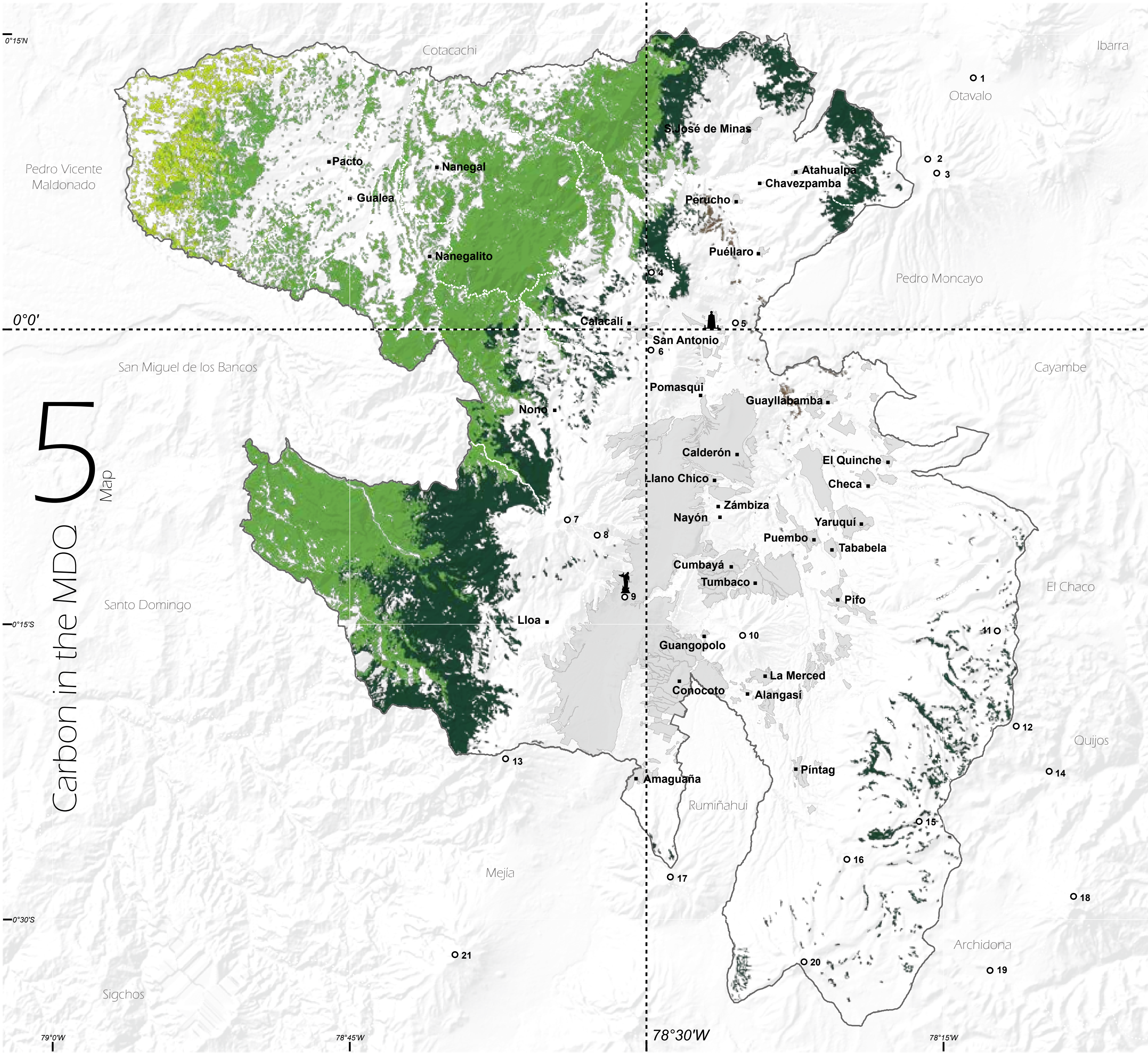
According to the IPCC, adaptation is the adjustment of natural or human systems in response to new or changing environments. Adaptation to climate change refers to adjustments in natural or human systems in response to actual or projected climatic stimuli, or their effects, intended to moderate damage or exploit beneficial opportunities. We can distinguish between various types of adaptation, including anticipatory and reactive, private and public, and autonomous and planned (*Infographic 11*).

Priority areas for adaptation

Vulnerability to the impacts of climate change varies within the territory and depends on socioeconomic conditions, the responsiveness of the population, and exposure to natural and man-made threats (Quito Climate Action Plan).

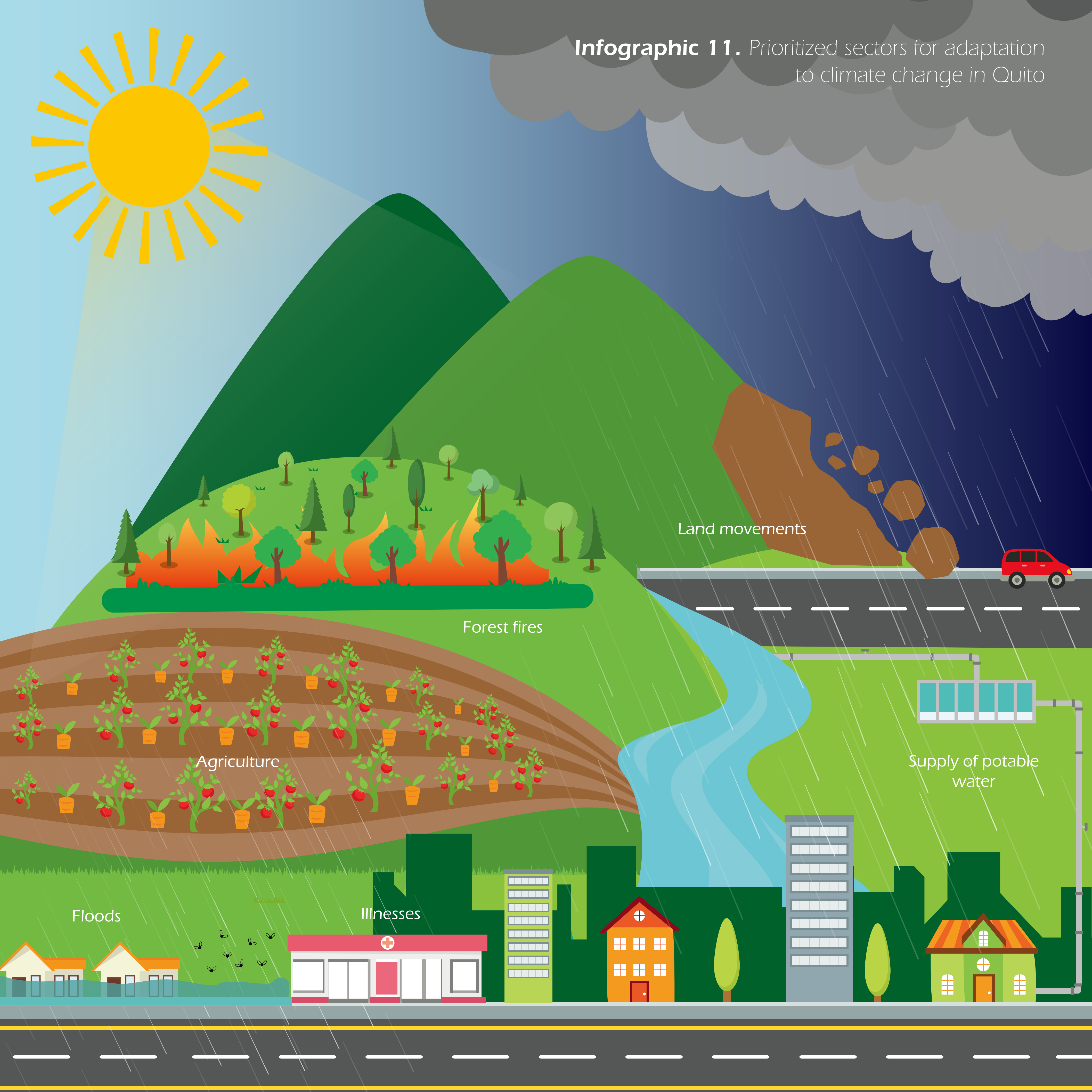
For this reason, the implementation of immediate measures to manage climate risks and natural disasters, which are based on information and mapping for prioritizing strategic areas and sectors of intervention, has been necessary.

5 Map
Carbon in the MDQ



Evergreen Andean piedmont forest
Evergreen Ceja Andean forest
Evergreen Andean montane forest
Dry Andean forest

Infographic 11. Prioritized sectors for adaptation to climate change in Quito



The cities and towns that understand climate changes today, and understand the possible behavior of future climate and prepare to face it, can be more competitive and less affected (resilient). The adaptation and mitigation measures that can be developed offer a range of possibilities and opportunities for the social, productive and economic development of local populations.

Taking steps today in order to be prepared for and adapted to global changes will be much more efficient than waiting to execute emergency measures, which are costly and often improvised. In the administrative centers of the Metropolitan District of Quito it is essential to pay particular attention to four priority areas for adaptation to climate change:

Water resource management sector

Hydrological systems are particularly sensitive to the occurrence of changes in precipitation or drought. Greater variability of climate events affects the balance of water resource units. Changes in water availability are, in turn, a factor of stress that can trigger conflicts between water users. It is estimated that some areas will be more susceptible to excess and others to low precipitation.

Adequate management and conservation of watersheds and wetlands will prevent agricultural production, water availability for human consumption, hydroelectric generation and the condition of ecosystems from being greatly affected.

The Fund for the Protection of Water for Quito (Fonag)

Fonag works within the direct area of influence of the upper basin of the Guayllabamba River and currently runs several programs through a financial mechanism to co-finance activities in the areas of: environmental protection, conservation and water recovery, community development, environmental education, monitoring and information management, among others.

This is of great importance due to an adaptive approach that ensures the quality and quantity of the resource in a scenario of vulnerability to climate change in the water sector, with greater empowerment of stakeholders.

Adaptation Strategy for the Water Supply Systems in the MDQ

The MDQ is in a vulnerable situation regarding water supply. The possible increase in average temperature and the increased presence of periods of drought could affect the water storage capacity of the paramo moors (Bradley et al, 2006).

- In this context, the ability of the soil of the paramo moors to meet its environmental function of storage and natural water flow regulation will be critical to society. To preserve the moors, the ability to arrange, plan, manage and monitor compliance with land use zoning between different actors is vital.

Photo: Germán Toaza

- The MDQ has an Adaptive Management Plan to facilitate management of the Pita-Puengasí system and its supply basins in a context of adaptation to climate change, with proposed policies and measures to reduce the impacts of this global phenomenon.

Scheme for the Reduction of and Compensation for the Water Footprint

Articulation and coordination with Fonag, EPMAPS and other bodies is very important for the management of climate change in this sector, the proposed strategies are as follows:

- Development and signing of inter-institutional agreements for actions focused on water issues to enable the possibility of joint projects or activities on adaptation issues.
- Generation and dissemination of information among agencies involved in climate change, vulnerability of water resources, and potable water systems, for the consolidation of adaptation plans for systems such as the supply of potable water.
- Find the linkages between the water sector and agriculture and urban and rural development, establishing visible criteria for adaptation measures.
- Strengthen existing inter-institutional synergies between the Participatory Urban Agriculture Program-Agrupar of the Metropolitan Economic Development Agency Conquito, the Secretary of the Environment and other local actors (parish councils).
- Establish strategies for involving the private sector (commercial, industrial and services) for compensating for the water footprint in the MDQ.

Climatic risks, resiliency and management sector

With temperature variation the risk of forest fires increases. In the case of the MDQ, dry ecosystems and paramo moors would be the most affected due to their climatic and environmental conditions. Forest fires affect fragile natural ecosystems, anthropic ecosystems, farming systems, forest plantations and infrastructure. Plans for prevention and sensitizing the population are important to prevent and control this problem.

Nationally, the importance of climatic events within the general context of disasters, is evidenced through information on deaths caused and destroyed or damaged homes, 68% of these events were of climatic origin in the period between 1970 and 2007 (MAE, 2011).

Quito is characterized by the confluence of a number of natural and anthropogenic factors encouraging the generation of phenomena that create instability.

The district coexists with a large number of risks, many of them related to dozens of ravines in the western geography, steep slopes composed of fragile volcanic material, high seismic exposure due to the presence of active faults and location in a volcanic region, human invasion into areas unfit for housing, wastewater discharge onto ravine slopes, overloading of slopes, deforestation, disposal of waste materials and debris on slopes and in stream channels, cutting of ravines for buildings and roads, among other factors.

In the case of landslides, the most vulnerable areas are those surrounding the urban area of the MDQ, located on slopes with high susceptibility.

In this context, an early warning system for climate risks in the MDQ has been created and comprises of response plans to climatic events such as forest fires and landslides.

The 'Plan for prevention and response to forest fires in the MDQ' is coordinated by the Municipality of the MDQ, through the Secretaries of the Environment, Safety and Governance, who directly coordinate actions with the MDQ's Fire Department.

The prevention and response plan for floods and landslides includes interagency coordination with municipal offices, to support people with medical, social and psychological care.

Resiliency Plan for Quito

In coordination with the 100 Resilient Cities organization, sponsored by the Rockefeller Foundation, the city will receive a platform for innovative services provided by membership of the 100 Resilient Cities network, support in creating a resiliency plan and a platform offering tools and resources to implement the resilience plan focused on four areas: finance, technology, infrastructure and land use, and social and community resilience.

This plan will allow the city of Quito to work together with some of the world's major cities through their respective local governments and the coordination and support of the 100 Resilient Cities organization to strengthen resilience in the MDQ, with the aim of providing greater and better security to the population of the city of Quito in the event of disasters.

Sustainable agriculture and rural development sector

The main impacts of climate change on the agricultural sector are evident on several fronts, including changes in the duration of crop growth cycle, changes in the incidence of frost, potential changes in the natural control of pests and diseases, changes in the incidence of average temperature and extreme minimum and maximum temperatures, and changes in rainfall patterns and periods of drought etc.

Climate change affects the four areas of food security: food availability, access to food, stability of food supplies and consumers' ability to adequately use food, including food safety and nutrition.

The adaptation of this sector consists of sustainably increasing agricultural productivity, improving the resilience of production systems and the local communities depending on them, and reducing greenhouse gas emissions (mitigation). These actions should be developed in the context of more efficient use of energy resources and the utilization of ecosystem services.

Participatory Urban Agriculture Project (Agrupar) - Conquito

This project originated in the Metropolitan Agency for Economic Promotion (Conquito), and operates from various dimensions of urban agriculture production: recreation, food security and sovereignty, occupational therapy, education, health, citizen participation and adaptation to climate change; the project is aimed at, among others, female heads of households, the elderly, the disabled, children, young people, schools, associations, refugees, migrants, and addiction recovery and social rehabilitation centers.

The aim of the project is to contribute to improving the quality of life of the most vulnerable people in the Metropolitan District of Quito through sustainable agricultural and livestock activities (small-scale), contributing to food and nutrition security, increased incomes, employment generation, environmental management, enhancing the landscape and raising self-esteem, through production, processing and marketing of organic products and animal husbandry, generated by production units.

The project seeks to strengthen the technical capacity of urban and peri-urban farmers as a contribution to food security, nutrition and human capital formation, and sustainably and safely increase agri-

cultural production and agribusiness with a focus on microenterprise management with access to different markets.

Pilot measures for adaptation to climate change in the MDQ's rural centers

The Secretary of the Environment is leading several projects with an adaptive focus, which are part of the Resilient City Program, including the 'Pilot Measures for Adaptation to Climate Change in the Metropolitan District of Quito' project for the sustainable agriculture sector, which contributes to increasing the resilience of agro-productive systems in rural areas to reach the territorial goal of reducing by 5% the area with moderate vulnerability to climate change by 2019, through participatory implementation of actions and the strengthening of local capacities.

In this context, the adaptation measures implemented under this framework requiring strong inter-institutional coordination, and constituting sustainable practices, promote the creation of integrated farms adapted to climate change.

These include crop diversification, composting and organic fertilization, integrated pest management, construction of rainwater reservoirs for both human consumption and agricultural irrigation, installation of efficient irrigation systems, use of terraces, construction of agricultural nurseries, the creation of seed banks to preserve biodiversity, and the recovery of degraded areas through agroforestry.

Health sector

Changes in climate affect human health, mainly through the appearance of diseases or the expansion of the range of diseases. These include: those diseases transmitted by vectors, the effects of extreme temperature episodes (for example those associated with heat waves or frost), viral diseases, etc.

Climate change influences the social and environmental determinants of health, because it is related to air quality, potable water, food security, and safe housing. According to estimates, between 2030 and 2050 climate change will cause some 250,000 additional deaths each year due to malnutrition, malaria, diarrhea and heat stress (WHO, 2015).

In the MDQ there is a high vulnerability to respiratory diseases in district's northwestern parishes with medium-low socioeconomic conditions, as these are found in areas where the rate of climate threat is high, in relation to the onset of these diseases. Meanwhile, the urban area of Quito has a moderate vulnerability rate which could increase to high in the case of extreme weather events increasing their frequency in the future as a result of climate change.

Moreover, it is likely that climate changes extend the transmission seasons of important vector-borne diseases and alter their geographic distribution. In that sense the MMDQ's Secretaries of the Environment and Health completed the participatory research project 'Vulnerability of the Health Sector in Quito: Facilitating technical data so they are accessible for decision makers', which focuses on assessing the situation of five tropical vector-borne diseases: Leishmaniasis, Chagas' disease, Malaria, Dengue and Chikungunya, against the risks associated with climate change, specifically in rural parishes in the Northwest of the MDQ: Nanegalito, Nanegal, Pacto and Gualea. The subject of health principally requires closer coordination with the Ministry of Health in order to socialize information and coordinate prevention efforts.

Policy for environmental quality management

> *To guarantee the right of citizens to live in a healthy environment, ensuring the quality of natural resources.*

The management of quality and resource status is multidimensional and is linked to different public policies such as production systems and consumption patterns.

In this context, a smart city understands that the state of natural resources is expressed as an open cycle or system with inputs and outputs of energy and matter. As such, natural resources are those moving within the flow of energy and matter in the environmental system, catalyzed by knowledge, technology and daily practices.

To guarantee the right of citizens to live in a healthy environment with quality natural resources, territorial and institutional synergies for the effective implementation of that right should be established.

Currently, the Metropolitan District of Quito, based on Accreditation Resolution No. 001 of January 6th 2015, issued by the Ministry of the Environment, which renews accreditation to the Cohesive Environmental Management System, is responsible for:

- Issuing environmental permits for activities of low, medium and high environmental impact (including industries, services, mining activities for the exploitation of freely available materials, service stations, storage facilities for liquefied petroleum gas), within the Metropolitan District of Quito.
- Reviewing and issuing pronouncements on environmental documents established in industry regulations such as the Environmental Regulations for Hydrocarbon Operations of Ecuador, and the Environmental Regulations for Mining Activities.
- Emitting environmental authorizations for collection, transport and solid waste management activities in the Metropolitan District of Quito.
- Providing environmental monitoring of activities with environmental permits within the Metropolitan District of Quito.
- Performing environmental control of activities that do and do not have environmental permits within the Metropolitan District of Quito.

The Directorate of Environmental Quality Management (DEQM) develops the environmental management system by applying the guidelines on regularization, monitoring and environmental control, subject to policies, direction, coordination and control, as part of the National Decentralized System of Environmental Management and the Cohesive Environmental Management system, administered by the Ministry of the Environment (*Figures 11 and 12*).

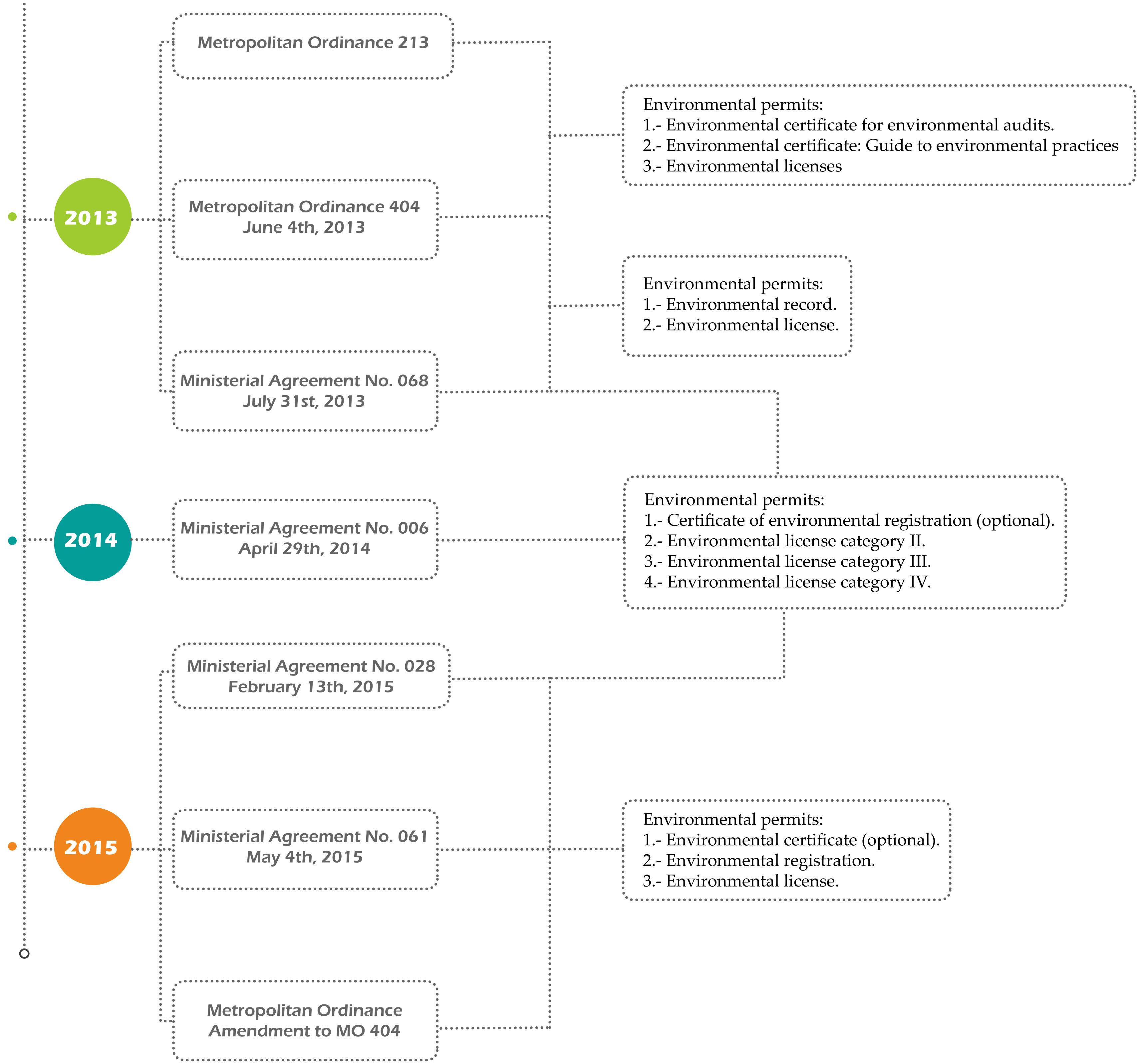
Figure 13 shows the goals and main strategic lines of action related to the quality of natural resources.

Environmental quality management

The Metropolitan District of Quito is a leader in environmental management in Ecuador and since December 6th 2004 has been accredited as a responsible Environmental Enforcement Authority within the Cohesive Environmental Management System.

The Ministry of the Environment exercises the power of National Environmental Authority and is steward of the National Decentralized Environmental

Figure 11. Chronological framework of environmental regulations



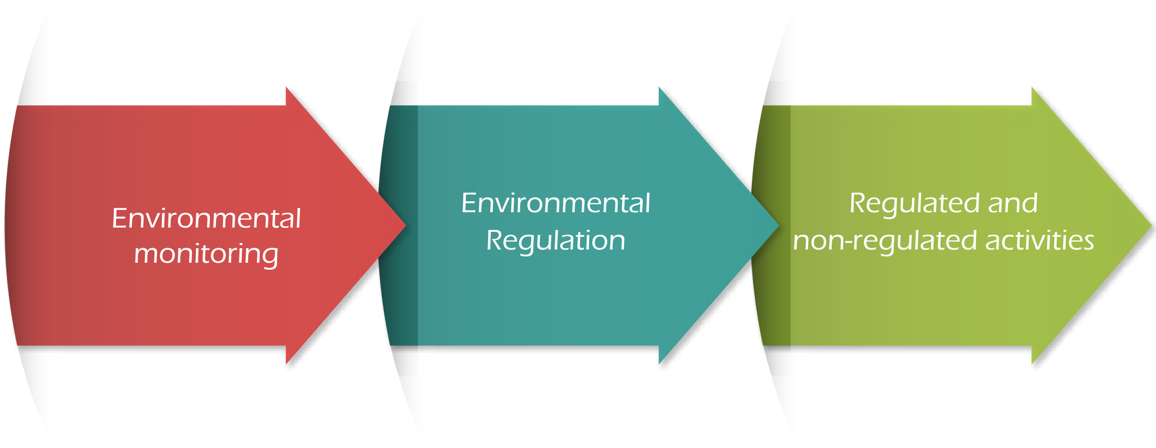
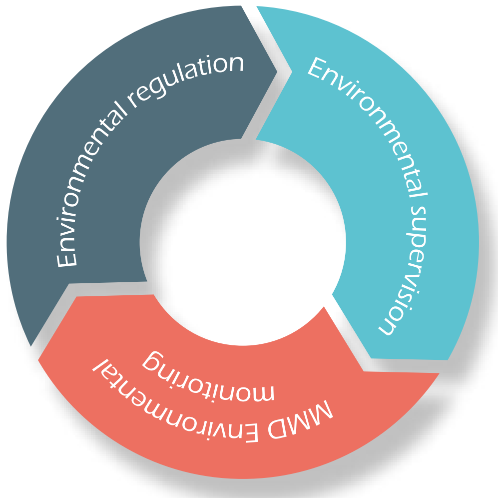


Figure 12. Environmental Management system in the MDQ



Management System, composed of decentralized autonomous governments accredited to the Cohesive Environmental Management System, as established by the Environmental Management Act, the Unified text of Secondary Legislation of the Ministry of the Environment (TULSMA), and under the powers granted in the Organic Code of Territorial Organization, Autonomy and Decentralization (COOTAD).

The Secretary of the Environment of the Metropolitan District of Quito, through the Directorate of Environmental Quality Management (DEQM), has the objective of establishing and regulating the stages, processes and requirements of the Environmental Management System (EMS) of the Municipality of the Metropolitan District of Quito, for the prevention, regularization, environmental monitoring and control of environmental impacts that diverse projects, works and activities can generate, both new and those that are already in operation within the territorial jurisdiction of the MDQ.

Thus, the municipality aims to improve the quality of life of the inhabitants of Quito and move towards being a sustainable city, based on the environmental principles embodied within the Constitution of the Republic and international instruments ratified by Ecuador, in accordance with the policies issued by the

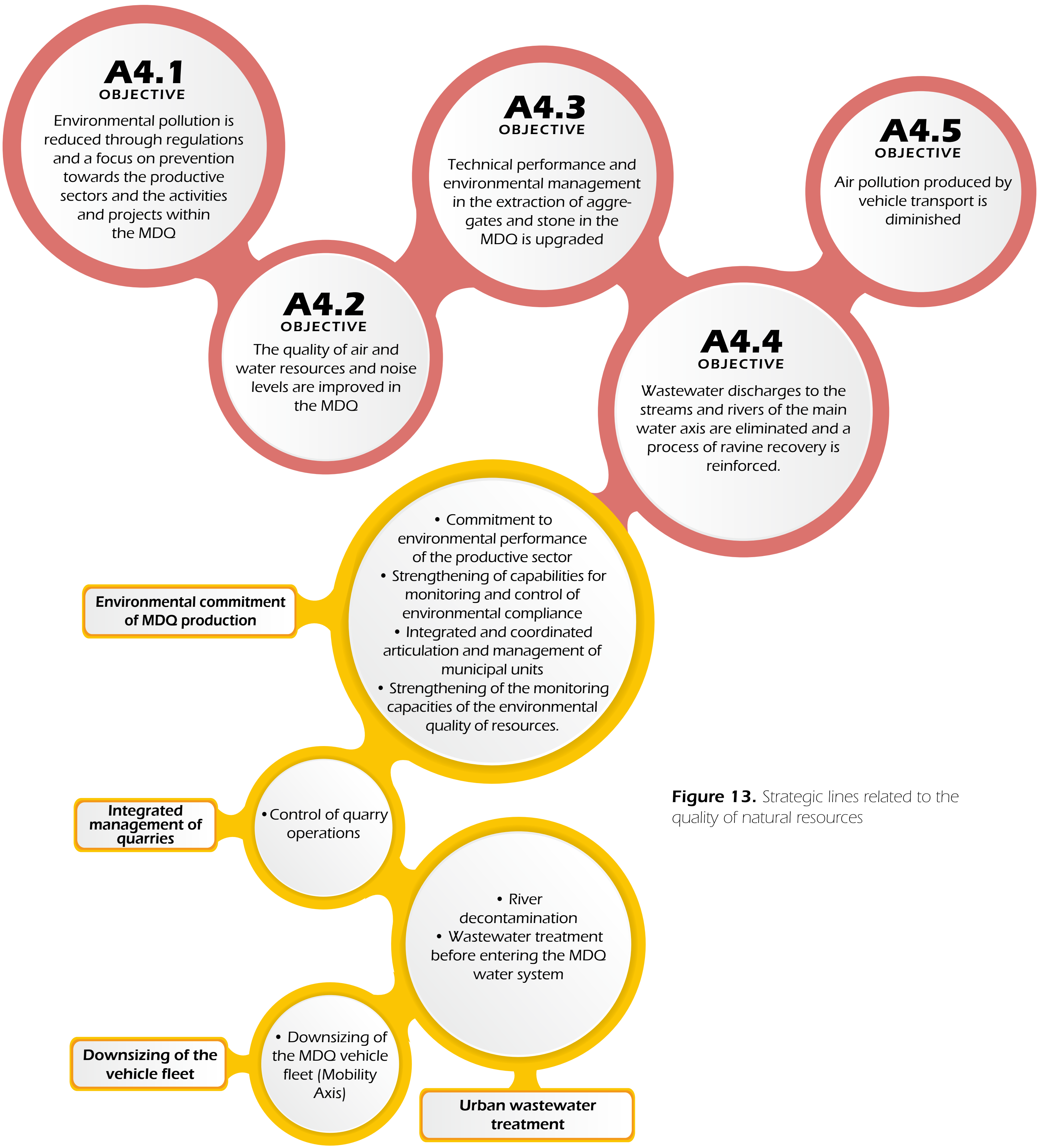


Figure 13. Strategic lines related to the quality of natural resources

National Environmental Authority and the procedures, mechanisms and instruments for regularization, environmental monitoring and control.

In the MDMQ approximately 20,000 projects, works and activities have been registered which are required to have an environmental permit in order to prevent, minimize, mitigate and offset any potential environmental impacts that may be generated by the development of the project, work or activity, and therefore to guarantee the right to live in a healthy, balanced and dignified environment for all the inhabitants of Quito.

Following is a presentation of the Environmental Quality processes for the MDQ:

Environmental regulation

The MDMQ is empowered to authorize the execution of public, private and mixed projects, works or activities, depending on their particular characteristics and the magnitude of their impacts and environmental risks. It is governed by the catalog of works, projects and activities issued by the Ministry of the Environment, through the Cohesive Environmental Information System (CEIS). Using instruments such as environmental studies and in compliance with current environmental regulations, environmental permits for works, projects or activities within the scope of its authority and jurisdiction are issued.

Environmental Monitoring and Control

Environmental Monitoring and Control is responsible for verifying compliance with the environmental obligations (administrative and technical) applicable to activities, works and projects.

The verification of compliance with environmental obligations can be motivated by internal coordination of the Secretary of the Environment or requests made by public and private institutions or citizens in general.

Mechanisms for environmental monitoring and control

Environmental monitoring and control can be carried out, among other ways, through monitoring and sampling, inspections, environmental compliance reports, environmental audits, action plans, emerging plans and mechanisms established in the regulations for specific activities.

Environmental Control resulting from applications submitted to the Secretary of the Environment

When an application submitted to the Secretary of the Environment requires the execution of a field inspection to verify compliance with environmental obligations, staff from the Directorate for Environmental Quality Management will generally perform the following activities: inspection visit to the establishment or activity, work or project, analysis of documentation (records, CEIS information) that may be related to the activity, work or project, and preparation of the respective reports, documents and memos.

Environmental Control coordinated by the Directorate of Environmental Quality Management

The Secretary of the Environment, through the Directorate of Environmental Quality Management, as a part of environmental control, and additionally due to environmental complaints and requests from other institutions, executes intensive environmental control operations in various sectors that are generating discomfort in the population. Among the sectors with interventions are:

- Mechanics, vehicle washing and lubrication.
- Bars, discos and karaoke venues. In this regard, in order to be effective in terms of results and administrative time spent during the processes of environmental control, the Directorate of Environmental Quality Management has led workshops with the Metropolitan Control Agency (the entity responsible for the exercise of the powers of instruction, resolution and implementation of administrative disciplinary procedures for contraventions established by Metropolitan Ordinances in force in the Metropolitan District of Quito), to ensure their active participation in the implementation of operations for controlling noise in the zonal administrations of the Metropolitan District of Quito.
- Slaughterhouses, poultry farms, barnyard animal breeding establishments located around the Mariscal Sucre International Airport.
- Environmental Control Plan for establishments in Calacalí parish.

The Directorate also maintains permanent inter-institutional coordination for effective response to environmental complaints from citizens, and participates in the creation and training of the Metropolitan Environmental Police, whose troops support control and environmental monitoring in the Metropolitan District of Quito.

Requirements submitted to the Secretary of the Environment

Requests for inspections submitted to the Secretary of the Environment, related to environmental problems evidenced by the public, have an application percentage distribution according to the zonal administration where the problems occur (*Figures 14 and 15*).

According to the requests for inspections submitted to the Secretary of the Environment, in the Metropolitan District of Quito citizens have denounced environmental problems according to the percentage distributions shown in *Figures 16 and 17*, in which the effects caused by noise have the highest percentage of complaints. The Secretary of the Environment, through the Directorate of Environmental Quality Management, has increased the frequency of noise control operations executed throughout the territory of the Metropolitan District of Quito.

Inter-institutional management led by the Secretary of the Environment

The Secretary of the Environment has led an inter-institutional effort between the Metropolitan Public Company of Potable Water Supply and Sanitation (EPMAPS), the Metropolitan Sanitation Company (Emaseo), the Metropolitan Company for Integrated Solid Waste Management (EMGIRS), Conquito, the Metropolitan District of Quito Fire Brigade, the Zonal Administration of Tumbaco, the Secretary of Planning, Habitat and Housing, the Health Secretary (Urbanimal) and the Metropolitan Public Enterprise for Airport Services (EPMSA), in order to control the management of organic waste generated by activities surrounding the Mariscal Sucre International Airport.

Inter-institutional coordination has allowed environmental remediation for the impacts generated by depositing organic waste in ravines near the Mariscal Sucre International Airport, where the following actions were taken:

- Operations for cleaning ravines and streams - The ravines are associated with the approach and take-off routes of aircraft from the Mariscal Sucre International Airport (AIMS). There, the Secretary of the Environment, through a team from the Directorate of Environmental Quality Management, coordinated the implementation

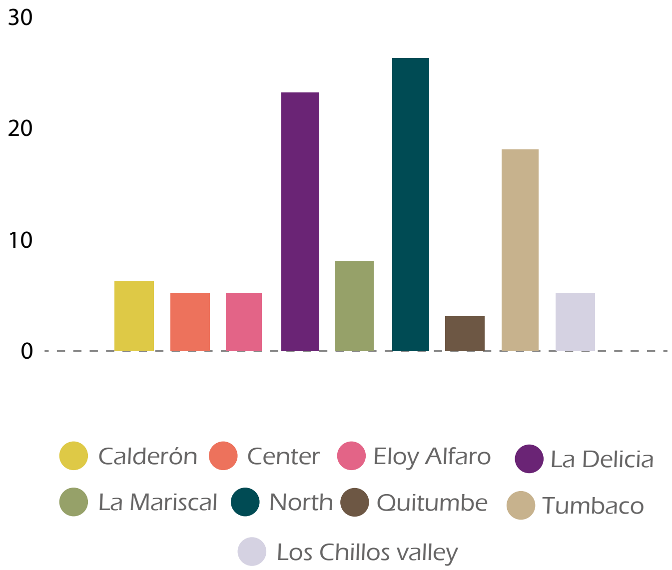


Figure 14. Percentage distribution of procedural paperwork according to MDQ zonal administration - 2014

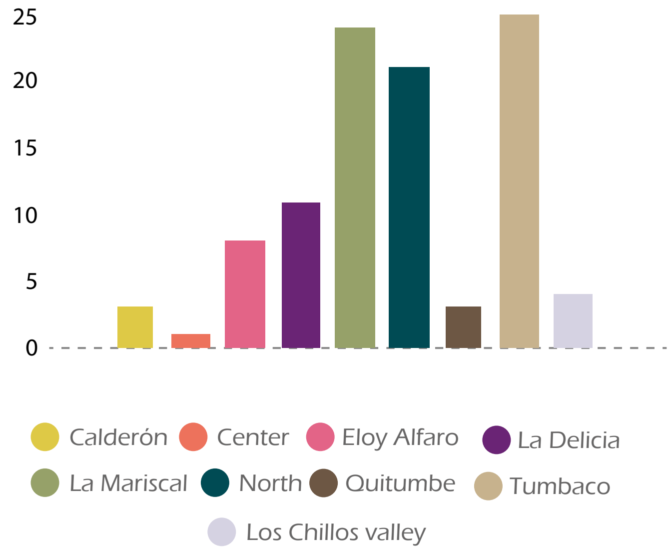


Figure 15. Percentage distribution of procedural paperwork according to MDQ zonal administration -2015

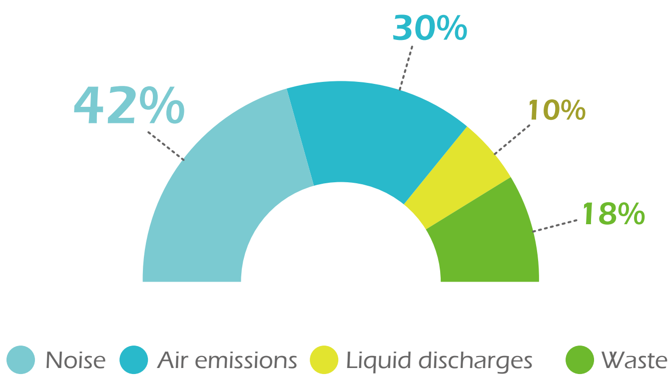


Figure 16. Percentage distribution according to the environmental impacts perceived by the citizens of the MDQ - 2014

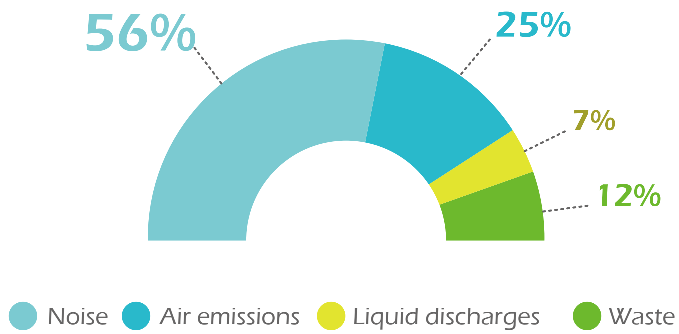


Figure 17. Percentage distribution according to the environmental impacts perceived by the citizens of the MDQ - 2015

of cleaning operations and secured the operational intervention of Emaseo, EPMAPS, AZT, QUIPORT, EPMSA and the MDQ Fire Brigade.

- Fencing off ravine edges - The Secretary of the Environment coordinated inter-institutional participation for the installation of fences and other measures at critical points of the ravines subject to clean-up operations.
- Planting trees: The Secretary of the Environment collaborated in the delivery and planting of trees at critical points in the enclosed ravines.
- Environmental awareness workshops - Targeting the population surrounding the Mariscal Sucre International Airport, to empower people concerning the responsibility for performing appropriate environmental management of the waste generated in their habitual activities.

Social participation in the environmental management of a project or economic activity

The process of social participation in environmental management is governed by the principles of legitimacy and representativeness, and is defined as an effort of state institutions, citizenship and the subject of control interested in performing a project, work or activity.

Social participation mechanisms are defined in terms of the level of environmental impact that can be generated and the level of conflict identified in a project or activity.

The application of the process of social participation in environmental management is governed in accordance with the requirements of national environmental legislation and under the procedures established by the Secretary of the Environment.

Wastewater treatment

Currently, according to data presented by the Metropolitan Public Company of Water Supply and Sanitation (EPMAPS) in September 2015, sewerage service coverage reaches a high percentage of the population, as seen in *Table 10*.

Table 10. Current percentages of sewerage coverage

Coverage of the Sewerage Service	Percentage
City of Quito	96.38%
Metropolitan District of Quito	92.57%
Rural parishes	83.23%
Wastewater treatment services	1%

While the collection of sewage is important for the health of citizens, it is necessary to mitigate the environmental impact of the discharge of wastewater generated. As such, a long-term program covering this need is planned: the ‘Program for the decontamination of the rivers of Quito’.

Rivers decontamination program

The ‘Program for the decontamination of the rivers of Quito’ aims for the integrated and adequate management of the liquid waste generated by the population (domestic discharges) and the productive activities of the city of Quito (industrial discharges) through interception, conduction and treatment of urban wastewater, so that the impacts currently derived from direct discharge into rivers and streams (*Infographic 12*) are minimized.

The specific objectives of the program for the decontamination of Quito’s rivers are:

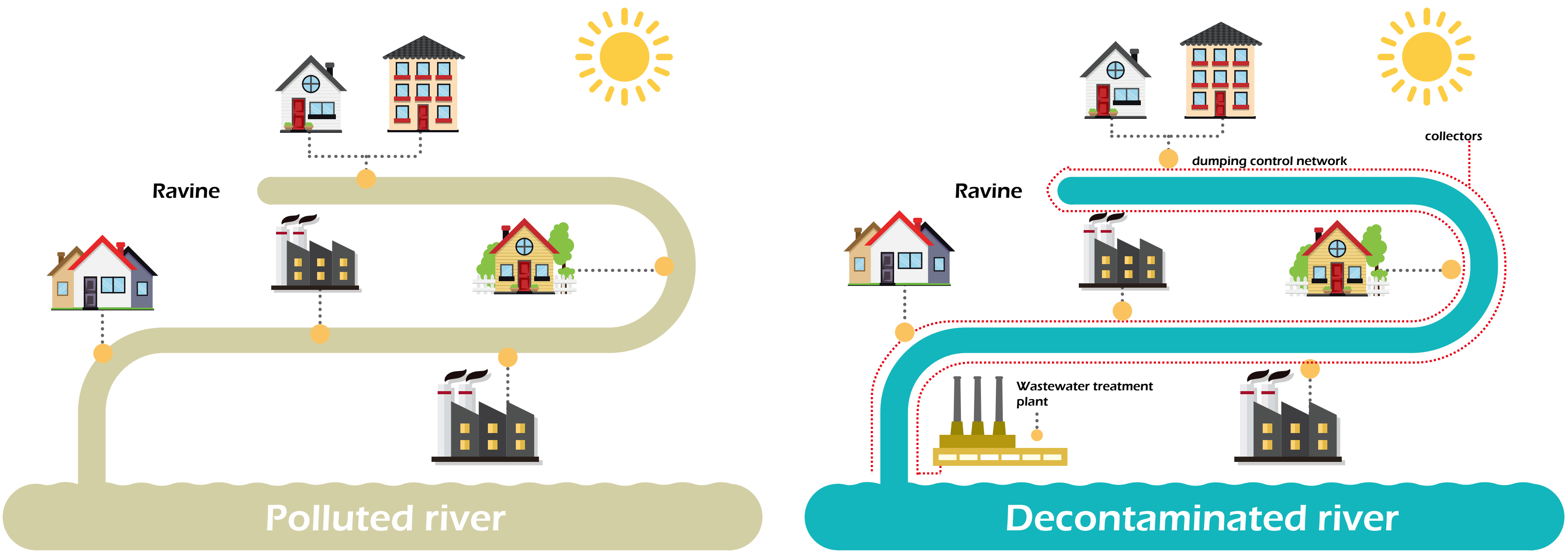
- Use clean technologies for the sanitation of domestic and industrial wastewater, through

processes of methane recovery and hydroelectric generation, which allow the environmental and financial sustainability of the project.
- Perform the work of interception (emissaries) and treatment of domestic and industrial wastewater.
- Recover, defend and preserve the beneficial uses and compliance with respective river water quality goals, in different sections of the high and middle basins of the Guayllabamba River.
- Comply with current environmental regulations and have in place environmental impact studies and environmental management plans for the project's works.

The project is of great importance because currently the Metropolitan District of Quito does not have the necessary facilities to treat 99% of the wastewater generated during the city's daily activities. Thus, the project is the 'first of its kind' and aims to treat citizens' wastewater and at the same time generate clean electricity by avoiding emissions of greenhouse gases. This will contribute to improving the quality of life of the population directly and indirectly involved in the project:

Because of its size, the project was divided into three components:

1. Southern Quito
2. Rural parishes
3. Northern Quito



Infographic 12. River interception system

First component: South Quito

The first component concerns interception works designed and built by the Corporation '*Vida para Quito*' (Life for Quito), between the sectors of Villaflora and Tola Baja. From the recommendations of the Feasibility Study of the Decontamination of the rivers of Quito Plan, conducted by Fichtner-Hidroestudios Association (AFH), it was necessary to complete the interception works executed by the *Vida para Quito* Corporation and extend them to the upper basins of the Machángara River's tributaries. The total investment in the first component amounts to 63 million US dollars.

Interception system

Currently, Technical Infrastructure Management (TIM) has both completed and ongoing network construction projects for sanitation interception from the ravine streams in southern Quito. A report from the Technical Infrastructure Management of EPMAPS indicates the following:

- The Grande River interceptors and groups two and four of the Machángara River are under construction, projects which will be completed this June. The planned investment amounts to 7 million US dollars.
- This year construction will begin on the interceptors of the Caupicho ravine with an investment of 5 million US dollars, and also on groups one and three of the Machángara River with an investment of 2.2 million US dollars, these projects will be completed by the end of 2018.
- In 2017, construction will begin on interceptors in the Capulí and Cornejo ravines, and rehabilitation of interceptors in the Shanshayacu ravine will be performed, with a total investment of 1.5 million US dollars, which by 2018 will complete decontamination in the south of Quito.

Water Recovery Plants (WRP)

The goal for the implementation of the WRPs is to deliver about 500 L/s of treated water to the tributary streams of the Machángara River, which will permit maintenance of optimum water levels for the recovery of aquatic ecosystems and to improve the quality of life of people who use linear parks, for a cost of near to 45 million US dollars.

WRP Quitumbe

This recovery plant will serve a population of 69,000 inhabitants, with a design flow of 108 L/s. The cost is 12,5 million US dollars, and the plant occupies an area of 1.5 ha. The progress of civil works is 95% and 60% of the equipment and accessories have been installed. By the end of 2016 the phase of assisted operation will begin.

Environmental conditioning

As part of the Integrated Ravine Stream Recovery Project in the MDQ, targeted interventions have been made in the ravines of southern Quito, the tributaries of the Machángara River and those found in the environment of the Quitumbe WRP: Shanshayacu, Ortega and Grande. Some of these actions included the resettlement of houses located within the protection areas of the streams. The monetary amount of these projects reached 7,3 million US dollars.

Second component: eastern rural parishes

The Second Component corresponds to the 27 rural parishes located in the upper basin of the Guayllabamba River. The cantons of Latacunga, Mejía and Rumiñahui were included and their proposals were developed to the level of feasibility. The study performed in the 15 parishes of the MDQ reached

Source: 'Wastewater Treatment Plant in Quitumbe' presentation (2014) EPMAPS

the final design phase, in which the grouping of these parishes into nine interception systems was determined, each with its respective Wastewater Recovery Plant. This study was funded by Technical Cooperation ATN11337, signed with the IDB, and finalized in 2013.

The cost of the work required to intercept and treat wastewater generated by the 15 parishes in the MDQ: El Quinche, Guayllabamba, Checa, Yaruquí, Tababela, La Merced, Píntag, Pifo, Puembo, Tumbaco, Cumbayá, Alangasí, Amaguaña, Conocoto and Guangopolo, is 134 million US dollars for the interception, and 53 million US dollars for the nine WRPs or treatment systems. The total investment of the second component amounts to 187 million US dollars.

Third component: the city of Quito and adjoining parishes

The study area of the Third Component includes the entire city of Quito and its six adjoining parishes: Pomasqui, San Antonio, Calderón, Llano Chico, Zámbiza and Nayón. In April 2011, EPMAPS approved the Decontamination of the Rivers of Quito Plan Feasibility Studies in which the optimal alternative for the city and adjoining and smaller parishes was established.

Through an inter-institutional cooperation agreement between LNP and EPMAPS, international public tender was issued for procurement of the study called 'Definitive Design of the works of Interception and Treatment of wastewater for Quito and adjoining parishes', and was won by the Hazen & Sawyer-Pi Epsilon Association,

with an execution plan of 600 calendar days for the amount of 9,190,655.16 US dollars.

Currently, the project is in the final stage of definitive design and addresses the treatment of wastewater from part of southern Quito, the entire center and north of the city, together with the Nayón, Zámbiza, Llano Chico, Calderón, Pomasqui and San Antonio de Pichincha parishes. In addition, it is intended to build the following:

- Emissaries: two emissaries to convey wastewater to the WWTP. The first, with an extension of 28 km, will carry the wastewater from a part of the south, the center and the north of the city from La Tola to the Vindobona WWTP. The second, 2.5 Km long, will transport wastewater from San Antonio de Pichincha to the Vindobona WWTP.
- Wastewater Treatment Plant (WWTP): A wastewater treatment plant activated with a staggered feed for nutrient removal, with treatment capacity of 7,550 liters (2045). The WWTP will have an anaerobic sludge digestion process for energy generation from biogas.
- Hydroelectric power: three hydroelectric plants with a combined generation capacity of approximately 40 MW. The first two take advantage of the gap that exists between the start of the pipeline and the Vindobona WWTP, and the last will use the discharge of treated water to the Guayllabamba River. These plants will cover the energy costs of the operation and maintenance of the WWTP. Surplus energy can be sold to the domestic electricity market.

Table 11 details the partial approximate costs of each project component. As we can note, the total value will be approximately 900 million US dollars, the estimated value to date (first quarter 2016).

Table 11. . Approximate partial costs of the Third Component

	Estimated cost (millions of USD)
Emission tunnel	350
WWTP	440
Hydroelectric Facilities	110
Total	900

In consideration of current legislation, the Law on Public Enterprises, Decree 582 of February 2015, and the recent Organic Law on Incentives for Public Private Partnerships and Foreign Investment, the legal and technical feasibility of undertaking projects with private sector participation has been established, to secure investment and create a long-term contractual relationship with EPMAPS for the recovery of its investment with an adequate return.

Financial engineering analyses defining alternatives for project implementation are being developed to verify which ones are feasible and attractive to the private sector.

The implementation of these projects is framed by Ecuadorian law and the internal regulation of EPMAPS.

When the three program components are implemented, the following results are expected:

- Decontamination of 276 km of rivers and streams of the MDQ, by building main emissaries and secondary marginal collectors, which convey wastewater to the WRPs.
- Water with a physicochemical quality allowing for uses such as recreation, aesthetics, irrigation, protection of aquatic life, and hydroelectric generation reservoirs.

EPMAPS should establish funding sources that allow the construction of these works, with schedules consistent with the reality of the city of Quito.

Due to scope and regional importance a contribution to the project from the national government is fundamental. Similarly, the establishment and implementation of decontamination and treatment fees is necessary to finance the operation and infrastructure maintenance, with the alternative being to charge the cost to industrial and domestic customers based on the corresponding pollutant load.

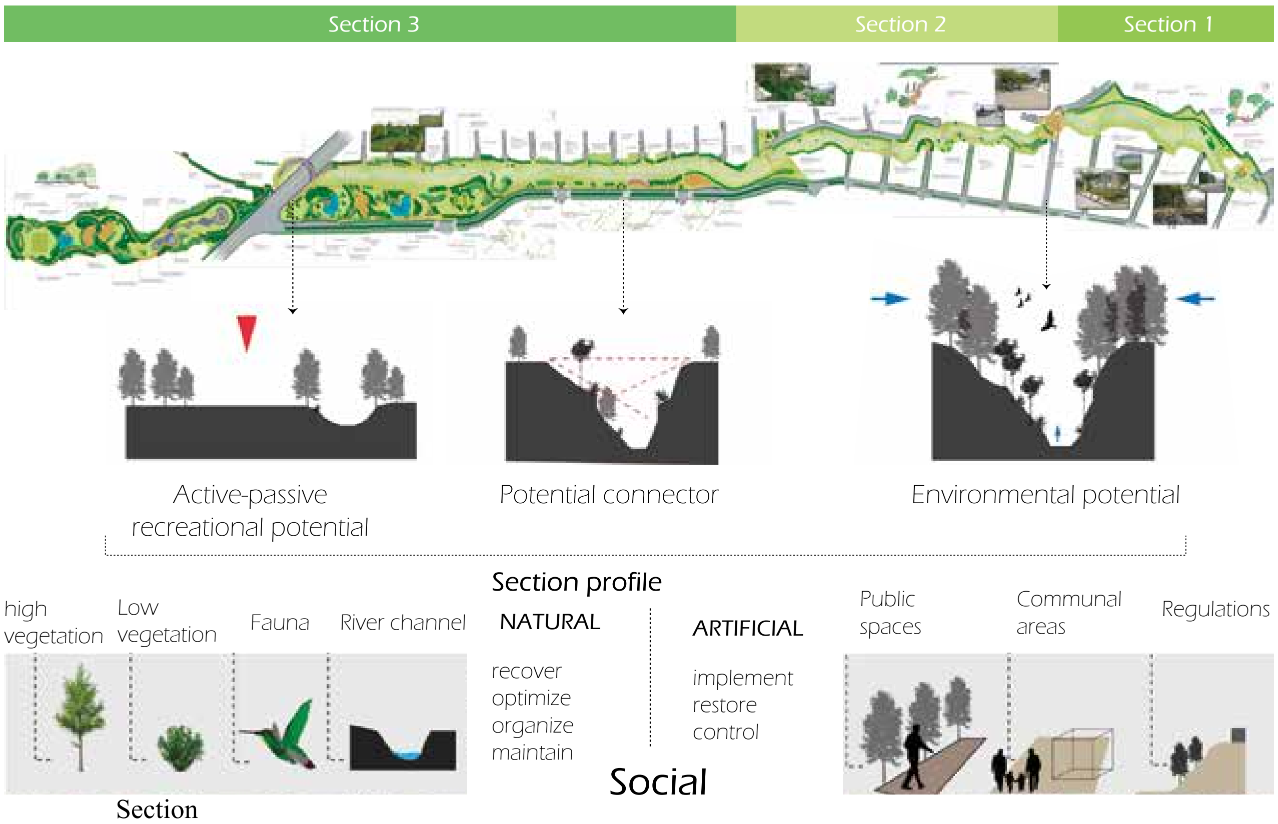
Making the management of wastewater at watershed level viable requires political agreements between the municipal administrations concerned, which will allow resources to be put in place, complementary studies to be conducted and the necessary works to be implemented within each jurisdiction.

Conditioning of ravines in the south of Quito

The Ortega (*Infographic 13*), Shanshayacu and Grande River ravines in the south of Quito (source of the Machángara River) occupy a combination of natural and urbanized areas that require intervention in accordance with the following approaches:

- Landscape improvement and environmental conditioning.
- Protection of channels to prevent flooding.
- Removal of homes located on the edges of the ravines.
- Reduction of landslides.

Infographic 13. The Ortega Ravine
Natural corridor with ecological potential




Before


After

Source: 'Wastewater Treatment Plant in Quitumbe' presentation (2014) EPMAPS

These activities are related to the interception of wastewater in Component 1 of the Decontamination of the Rivers of Quito Plan. Also included is the environmental conditioning of several small streams to allow the creation of ecological corridors and improve the quality of life of residents living near to these ravines and streams (*Table 12*).

As an example of the environmental conditioning taking place in the 'Decontamination of the Rivers of Quito Plan' project, the Ortega ravine has been recognized as a place of leisure and as an ecological corridor due to its recreational potential, its potential as a connector and the variety of fauna and flora found in the area (*Infographic 13*).

Table 12. Environmental conditioning work – First Component

Planned actions	Investment cost (USD)	Work completion
Navarro La Raya (Group 1)	780,874	07 - 2012
Navarro La Raya (Group 2)	708,343	07 - 2012
Navarro La Raya (Group 3)	400,233	02 - 2012
Ortega ravine conditioning	1,165,851	08 - 2014
Hydraulic work Ortega Ravine	1,300,000	04 - 2014
Hydraulic work Rio Grande Ravine	780,874	07 - 2012
Environmental conditioning Rio Grande Ravine	1,033,630	08 - 2012
Environmental conditioning Shanshayacu Ravine	580,000	11 - 2014
Total cost	**7,256,034.00**	

Source: Project profile 'Decontamination of the Rivers of Quito Plan', EPMAPS (2015)

Policy for the management of Environmental Good Practices

To promote in citizens the principles of the sustainable city supported by joint commitments that manage to influence the production, behavior and consumption patterns of all MDQ sectors.

Promoting a culture of Environmental Good Practice (EGP) is critical to building a sustainable city and requires the joint efforts of the municipality with citizens, neighborhoods, educational institutions, businesses and civil society organizations. EGPs are a set of simple actions that involve a change in attitude and behavior of people in order to enjoy a friendlier relationship with the environment.

Figure 18 shows the main objectives and strategic lines of action related to Environmental Good Practices:

Management of Environmental Good Practices

For the implementation of EGP the Secretary of the Environment of the Metropolitan District of Quito has defined a set of tools and programs to enhance the participation of citizens in order to encourage a friendlier relationship with the environment. Below, the three most important programs are presented:

1. EGP program for different sectors
2. Metropolitan Environmental Distinction: Sustainable Quito MED SQ
3. Environmental volunteers

EGP program for different sectors

To implement EGP in homes, neighborhoods, educational institutions and productive and service activities, the Secretary of the Environment has designed a simple methodology, which applies to any institution and consists of four stages: 1) Formation of an environmental team, 2) Diagnosis of resource consumption and waste generation, 3) Design and implementation of preventive and corrective measures, and 4) Monitoring and reporting Plan (*Figure 19*).

Based on this methodology, the Secretary of the Environment has implemented specific projects in various sectors, among these are municipal institutions, educational institutions, markets, small businesses and neighborhoods.

Municipal institutions

Aware of the importance of beginning in our own institution, the Secretary of the Environment has designed the 'In-house EGP' project. This project implements the EGP methodology in municipal institutions.

This project began in 2014 and to date some activities that strengthen the municipality's environmental management have been performed. The main activities are:

- Consolidation of the environmental teams leading program activities in municipal institutions and reporting on these so that the Secretary of the Environment can keep track of data throughout the municipality.
- The 'Tidy your desktop', 'Tidy your files' and 'Tidy your warehouse' campaigns. These campaigns consisted of activities in municipal institutions for employees to order the different areas of their institutions, separate recyclable materials and identify equipment and materials that were obsolete or could be reused.

Figure 18. Objectives and strategic lines of action related to Environmental Good Practices.

Figure 19. Methodologies for the implementation of EGPs

- Internal communication channels to share EGP messages and actions performed by each institution.
- Participation of municipal institutions in the Metropolitan Environmental Distinction: Sustainable Quito MED SQ

In 2016, a schedule of activities for the whole year was defined, and each month environmental teams send reports of implemented activities.

Educational institutions

In 2015, the Secretary of the Environment implemented, with the support of the Environmental Headquarters of the MDQ's Zonal Administrations, the 'zero waste' project in more than 30 educational institutions. This project involved application of the EGP methodology with a special focus on waste management, as this is one of the major environmental problems.

Environmental teams were made up of students, teachers, administrators and maintenance personnel. These teams performed consumption and waste characterization diagnostics and defined targets to reduce waste generation and improve waste classifications to aid recycling.

For 2016, the Secretary has a manual for educational institutions on its institutional website. This manual can be downloaded for free and guides the EGP implementation process.

Work in educational institutions has a positive impact on the city because children and young people are made aware of the importance of reducing negative impacts on the environment and become advocates who encourage their relatives and neighbors.

Markets and small businesses

If we consider the total number of economic activities in the MDQ, it is clear that a high percentage corresponds

to small businesses, which need not perform an Environmental Impact Study as their impact on the environment is small.

Similarly, markets are a very important facet of the city where most people buy their food, and are also places with very important social dynamics for the city.

For these reasons, the Secretary of the Environment has designed 'EGP in your business', which seeks to motivate markets, neighborhood shops, restaurants, and other activities to implement the EGP methodology.

The main objective of this project is to raise awareness among traders of the importance of implementing simple actions that are within their power in order to improve the environmental performance of their businesses and thus improve their image and get more customers.

Metropolitan Environmental Distinction: Sustainable Quito MED SQ

The Secretary of the Environment of the Municipality of Quito, in fulfillment of its mission to promote a culture of Environmental Good Practices, reduce footprints and encourage the active participation of citizens, has designed the Metropolitan Environmental Distinction: Sustainable Quito MED SQ (*Infographic 14*).

The MED SQ is a channel of communication with the public that allows participating individuals, neighborhoods and organizations to assess their environmental performance, to find out what actions can be implemented to improve their relationship with the environment, while also highlighting the various actions implemented by citizens that serve as a model for all inhabitants of the MDQ.

The main objective of the MED SQ is to publicly distinguish the best environmental practices implemented by individuals, neighborhoods, organizations and companies in the MDQ, and to recognize the will, progress and achievement in the implementation of actions related to care for the environment and the reduction of footprints.

To create the Distinction, at the end of 2014 and during 2015 the Secretary of the Environment conducted nine technical working groups and several meetings with representatives of different public sectors to define the main environmental problems of the MDQ, as well as indicators for each topic. In addition, the district had the support of sustainability experts in the UK from the Universities of Nottingham and Cambridge and Business in the Community.

Participants in each category perform a self-assessment on the MED SQ platform and those who obtain a higher rating than the percentages defined in the MED SQ baselines can attain one or more honorable mentions, or the Environmental Distinction according to their performance in all dimensions. It is important to note that after a self-assessment the Secretary of the Environment, through a jury of experts, visits participants with the highest scores to evaluate their results.

Each of the indicators should be evaluated on a scale of 0 to 5 (*Figure 20 and Table 13*).

To validate the results and define the winners of the Distinction award, the MED SQ Council of Honor was formed. This Council is composed of representatives of institutions that, in turn, represent different sectors of the population and are recognized for their work and seriousness. The formation of the Council of Honor is described in *Table 14*.

Results of the MED SQ 2015 edition

The first edition of the Metropolitan Environmental Distinction: Sustainable Quito was performed in 2015. In that edition 129 participants were registered

Individuals	
Legal entities	• Private companies (banks, insurance companies, industries) • Public companies (local government) • Educational institutions, universities
Neighborhoods	• Urban sector • Rural sector

Figure 20. Categories and scope of the MED SQ

Table 13. MED SQ Evaluation range

Evaluation	Level
0	No progress
1	Will to begin an action
2	Initiated action
3	Action in progress
4	Action completed and results evaluated
5	Action implemented for more than 3 years

from different categories: individuals, legal entities and neighborhoods of the MDQ. Of this number of participants, 110 were eligible and 64 completed all stages of the MED SQ.

Figure 21 shows the results of the participation of individuals, legal entities and neighborhoods.

In the 2015 edition three companies and one individual won the Metropolitan Environmental Distinction: Sustainable Quito. In relation to Honorable Mentions, three individuals, three neighborhoods and three companies obtained this recognition in different categories.

Based on the results of the first edition, for MED SQ 2016 changes are being considered which take into account the views and observations of the Council of Honor and comments from participants.

The main changes implemented are:

In the Legal Entities category, 12 subcategories were included for participants to evaluate their peers. The subcategories considered are:

Table 14. Council of Honor of the Metropolitan Environmental Distinction: Sustainable Quito (MED SQ) 2016

Marianela Curi	Latin American Future Foundation (LAFF)
Alfonso Abdo	Metropolitan Agency of Economic Development (Conquito)
Galo Medina	The Nature Conservancy (TNC)
Ana María Noguera	Chamber of Industry and Production (CIP)
Xavier Tinajero	Quito Chamber of Commerce (QCC)
Boris Cornejo	Permanent Forum of Quito
Laure Belfiore	Global Pact of the United Nations
Elena Espinoza	Business In The Community (BITC)
Miriam Manobanda	Federation of Neighborhoods
Roberto Salazar	S2M Foundation
Verónica Arias	Secretary of the Environment
Rodolfo Rendón	Ecuadorian Council of Sustainable Building (CEES)

1. Large Productive and Industrial Sector (more than 200 employees)
2. Medium Productive and Industrial Sector (From 51 to 199 employees)
3. Large Trade and Services Sector (more than 200 employees)
4. Medium Trade and Services Sector (51 to 199 employees)
5. Small businesses in all sectors (11 to 50 employees)
6. Microenterprises in all sectors (1 to 10 employees)
7. Universities, Polytechnics and Institutes of Technical and Further Education
8. Other Educational Institutions

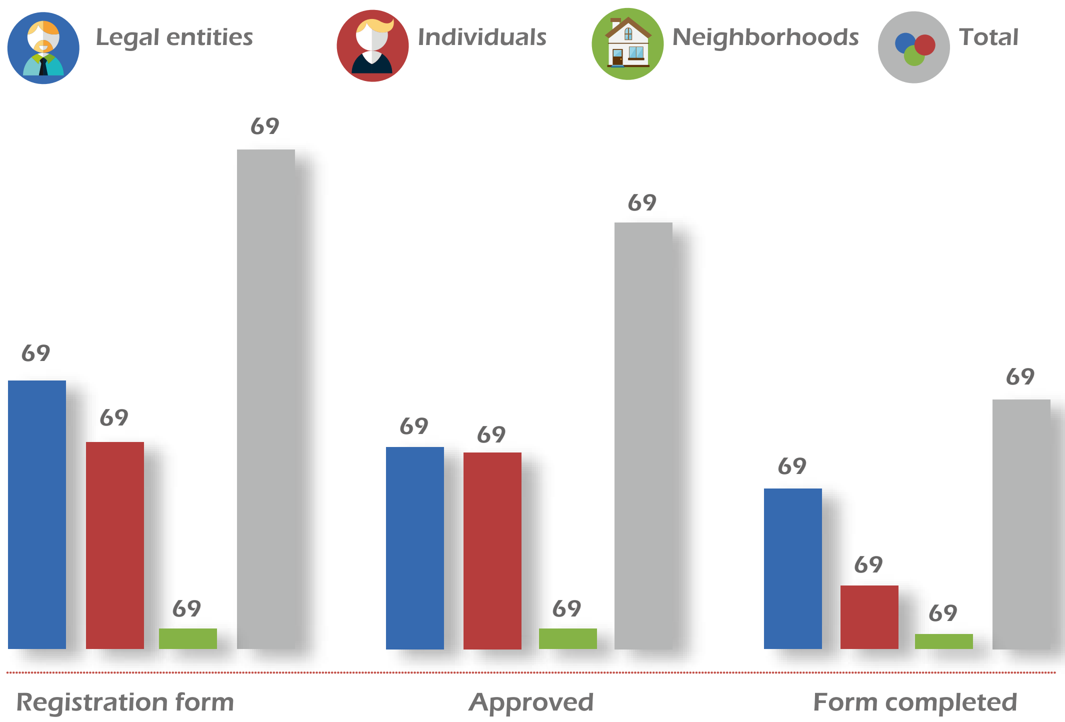


Figure 21. Results of participation in the MED SQ in 2015

Table 15. Percentages required to obtain an Honorable Mention or Environmental Distinction

LEGAL ENTITIES	MIN	MAX
1. Subcategory: Large Productive and Industrial Sector (more than 200 employees)	43%	85%
2. Subcategory: Large Trade and Services Sector (more than 200 employees)	43%	85%
3. Subcategory: Productive and Industrial Sector (From 51 to 199 employees)	38%	75%
4. Subcategory: Medium Trade and Services Sector (51 to 199 employees)	38%	75%
5. Subcategory: Small businesses in all sectors (11 to 50 employees	30%	60%
6. Subcategory: Microenterprises in all sectors (1 to 10 employees)	30%	50%
7. Subcategory: Markets	30%	50%
8. Subcategory: Universities, Polytechnics and Institutes of Technical and Further Education	38%	75%
9. Subcategory: Other Educational Institutions	30%	60%
10. Subcategory: Public Enterprises	43%	85%
11. Subcategory: Other Public Institutions	33%	65%
12. Subcategory: NGOs and Civil Society	30%	60%
INDIVIDUALS	30%	60%
NEIGHBORHOODS	30%	60%

9. Markets
10. NGOs and Civil Society
11. Public Enterprises
12. Other Public Institutions

Regarding the percentages for obtaining an Honorable Mention or Environmental Distinction, these were reviewed for each Category and Subcategory, considering the results of the first edition. The new minimum and maximum percentages are presented in *Table 15*.

Regarding MED SQ indicators, in the first edition 51 indicators were used distributed among the various environmental dimensions. For 2016, the number of indicators was reduced to 34 with descriptions of the indicators belonging to each category or subcategory. This ensures that the process is simple and evaluation corresponds with the reality of each sector.

Environmental volunteers

The basis for the construction of a Sustainable Quito is the active participation of citizens. In this regard, the Secretary of the Environment considers the participation of representatives of each sector to be the linchpin for implementing the EGP program, as well as the voluntary support of citizens, university students and volunteers from businesses to implement the aforementioned projects.

For the participation of volunteers in projects implemented by the Secretary of the Environment, agreements were signed with universities and higher education institutions to have the support of students under the 'Links with the community program', which is a requirement for obtaining a university degree.

In 2015 and 2016 the participation of university students has been incorporated into some EGP projects, among these are the Chiriyacu, Iñaquito and Comité del Pueblo markets, and businesses in the Jipijapa and La Mariscal areas.

Photo: Martín Jaramillo

El Ejido Park, cycle path

Infographic 14. MED SQ 2016

Sustainable mobility

1. I promote and/or provide incentives to people who walk or use non-motorized transport.
2. I provide a corporate transport service and more than 50% of my employees use it.
3. I promote the use of private bicycles or the 'Biciquito' public system.
4. I implement and maintain suitable infrastructure to facilitate non-motorized mobility. (exclusive car parks, adequate routes, signage)
5. I include in my policy and/or internal regulations the fostering of non-motorized mobility.
6. I promote the shared use of private and corporate vehicles, and taxis.

Environmental Good Practices to reduce footprints

7. I measure my carbon footprint and/or my water footprint.
8. I possess a certificate of carbon-neutrality.
9. I collaborate in, sponsor, support, fund and leverage initiatives, projects, and actions related to climate change presented by people or neighborhoods in my environment.
10. I conduct awareness campaigns about climate change from environment footprints and how to reduce those footprints.
11. I integrate measures of reduction and/or compensation for footprints in my activities.
12. I implement programs of gradual substitution of combustible fuel and/or use of renewable energy.
13. I reduce the use of detergents and other cleaning products and use biodegradable products to avoid river contamination.
14. I promote and/or offer incentives for the efficient use of water, energy, paper and other supplies.
15. I buy environmentally friendly products and prioritize local products.
16. I record my water and energy consumption and I implement measures to reduce usage.
17. I use technology and equipment with environmentally friendly characteristics and components.
18. I promote the non-use of plastic disposable bags and bottles
19. I have established and comply with the criteria for responsible consumption.

Care for Natural Heritage

20. I implement and/or take part in programs for recovery, care and/or maintenance of ravines.
21. I implement and/or participate in programs for the care and preservation of species of flora and fauna in the MDQ.
22. I participate in programs for the protection of urban woodland and/or reforestation and we are alert to their conservation status.

Adequate Waste Management

23. I promote the application of the 4Rs to coworkers, suppliers, and clients.
24. I apply the 4Rs in waste management.
25. I organize and participate in waste-cleaning campaigns in specific areas.
26. I gradually reuse waste as a raw material in my products.
27. I verify that my suppliers of products or inputs reduce waste in their companies or environments.
28. I reduce the quantity of packaging for my products / I use reusable/recyclable materials in my packaging.
29. I separate and properly dispose of used vegetable oils.
30. I reuse organic waste to create fertilizers, humus or other products.

Sustainable construction

31. I use energy from renewable sources in my premises.
32. I apply energy efficiency criteria and take advantage of natural sunlight.
33. I implement green terraces, vertical gardens and vegetable gardens.
34. I possess the necessary infrastructure to collect and use rainwater and/or reuse wastewater.

Citizen participation and co-responsibility

The complex and diverse man-territory-development relationship is the transversal axis of Environmental Management. Intuitive, intelligent, active and committed participation of citizens is inserted into the strategic areas of the Metropolitan Development and Territorial Management Plan as it is vital to management in the coming years.

Building a sustainable, supportive, intelligent, equitable Quito with opportunities for all occurs within the framework of broad participation and consultation linked to decision-making to promote participatory mechanisms in the entire public policy cycle.

Currently, efforts to understand climate, productive, ecosystem, urban and cultural interrelations are linked to the natural and human environments around us, as described in this *Environmental Atlas*, and require profound reflection of the problems, limitations and opportunities with different actors to improve the dynamics of social construction between entrepreneurs, chambers, industry, academia and citizens, organized territorially or by interest groups to constitute an institutional counterweight.

In this context, the participation of citizens is an exercise of coexistence in which the citizenship seeks to be duly informed and trained so that it can actively contribute in the construction of policies, plans and programs; this voluntary dynamic sustains and encourages institutional action.

Another important element of citizenship is responsibility to the city, which includes being ready to correct and modify behavior to adapt to practices that are friendly to the environment, within parameters of responsible consumption that do not compromise the future resources of fellow citizens.

In this scenario, the MDQ seeks to strengthen the social fabric, with mechanisms for citizen participation in observatories, councils, volunteer programs, forums and thematic working groups, which consolidate orientation mechanisms towards sustainable development.

Undoubtedly, awareness and co-responsibility constitute an important factor in strengthening social development and the planning of actions by the Secretary of the Environment, and is reflected in different plans: the Natural Heritage Management Plan, the Quality of Resources Plan, the Climate Change Plan and the Integrated Waste Management Plan.

ENVIRONMENTAL FUND

Environmental Funds (EFs) were born following the Earth Summit in Rio de Janeiro in 1992. These are organizations that act as key financial mechanisms and facilitate the implementation of policies and actions for conservation and sustainable use of biodiversity. These funds complement government actions and encourage the participation of civil society in the conservation of natural resources, reconciling global environmental demands with national priorities and realities. Thus, EFs are established as private, public or mixed organizations.

On May 20th 2005, through Metropolitan Ordinance 0146, Art.II.383.1, the Environmental Fund of the Metropolitan District of Quito (MDQ) was created with the objective of financing plans, programs, projects and any other activities contributing to the protection, conservation and improvement of natural resources and environmental quality in the district, in accordance with environmental priorities and policies established by the Municipality of the Metropolitan District of Quito (MMDQ).

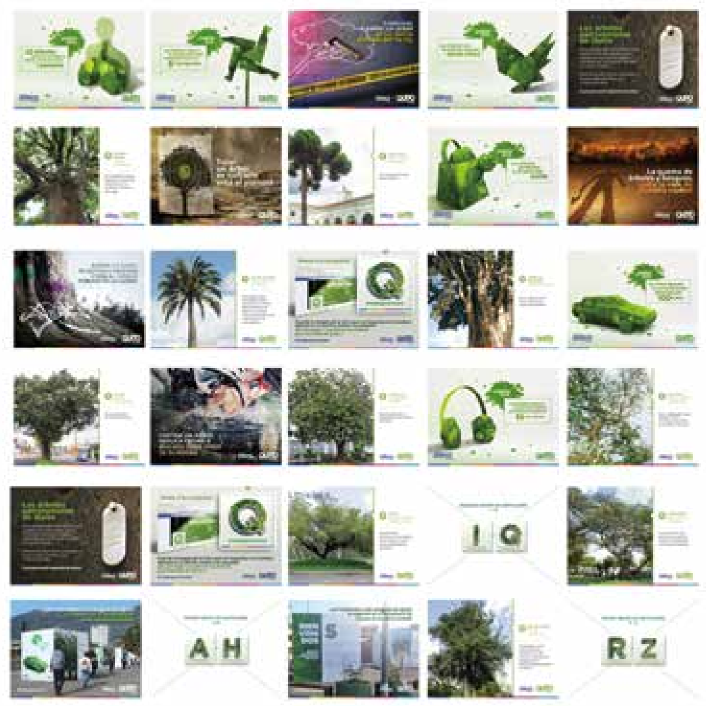
The Environmental Fund is an Autonomous Public Institution attached to the MMDQ, and works closely with the Secretary of the Environment, the governing body for policies on the environment in the MDQ.

Environmental Fund resources come from environmental fees and fines as well as donations from domestic and foreign individuals or corporations, and are used to finance annual or multi-annual investment projects framed by the Environment Sector Strategy of the MMDQ.

Within the framework of investment projects, the Environmental Fund has ‘Grant Funds’, in which the resources and initiatives of the Municipality and citizens converge in environmental projects to benefit the city, and are a source of financial resources with which Quitenian society can facilitate and support the management of environmental quality and the conservation of its natural heritage, to strengthen citizen participation in the environmental management of the district.

From its inception to the present, the Environmental Fund’s resources have been distributed as follows: 39% goods and services, 36% collaboration agreements, 21% staff, 4% long-term assets.

Among the projects financed by the Environment Fund we can highlight the following:



Quito Climate Pact

Between June 1st and 5th 2011 the First National Summit of Local Authorities entitled ‘Quito Climate Pact’ took place, an initiative that aimed to establish a historic milestone for promoting actions, which from the local level, contribute to reducing greenhouse gas emissions and adapting cities to the impacts of climate change, based on a commitment of co-responsibility and solidar-

ity. With the participation of 2,000 people from various sectors (national and local government, academic, private, public, NGO, cooperation, among others), the 'Quito Climate Pact' was signed and the national system of local climate change actions was launched.

The Quito Climate Pact, proposed and endorsed by the MMDQ on June 3rd 2011 and ratified by the Metropolitan Council of Quito in Ordinary Session on June 23rd 2011, has allowed integration of environmental management implemented by the different municipal institutions, the implementation of innovative approaches to climate change in local management, the sensitization of different sectors of the population to this global problem, and the identification of a set of environmental good practices as options for affecting change in environmental culture.

Ordinary General Assembly of Comaga and the Annual Monitoring Meeting of the Quito Climate Pact - Lago Agrio 2012

Based on the commitment assumed by the Metropolitan District of Quito and in order to assess the progress of the Quito Climate Pact initiative, the significant support of the Consortium of Amazon and Galapagos Municipalities (Comaga) and the Lago Agrio Autonomous Decentralized Municipal Government was added to the initiative. The Annual Meeting of Quito Climate Pact Monitoring together with the Ordinary General Assembly of Comaga was held from November 14th to 16th 2012 in the city of Lago Agrio.

The Assembly was attended by several of the country's mayors, leaders of community and neighborhood organizations, as well as local students and representatives of the media, in an open and direct dialogue on policies and actions to address climate change in the country.

The thematic discussion groups were able to discuss issues relating to local public policies; among these were territorial and solid waste management, participation and civic co-responsibility, water and sanitation, conservation of natural heritage, renewable energy and sustainable mobility.

Green Quito Eco-fair 2012

The Green Quito Eco-fair 2012 took place in the Quito Exhibition Centre, from June 29th to July 1st 2012. Its main objective was to provide a space in which the district's key actors, both public and private, could share with citizens alternative technologies, services and products designed to improve and preserve the environmental quality of Quito.

Its specific objectives were to:

- Understand that the future depends on how we live today, on our actions and our responsibility to the environment.
- Inform the public about the programs, projects and actions which Quito and Ecuador have developed to improve the environment.
- Encourage environmentally positive attitudes to build a Green Quito today and tomorrow.

The topics discussed included: animal and plant protection, recycling, ecological products, education and research, climate change, volunteerism, architecture and sustainable design, energy efficiency and environmental good practices.

The results obtained are summarized as follows: 9,318 visitors, 79 exhibitors, 68,368 visitors in Facebook, 542 Twitter followers and 1,466 tweets.

Grant funds

The 'Birds, tourism and agro-production: Reconciling Local Development with the Conservation of the Protected Natural Area Mashpi-Guaycuyacu-Sahuangal in the Metropolitan District of Quito' project, secured a contribution from the Environmental Fund of USD 77,000, received by the winning organization: the Ecuadorian Foundation for the Research and Conservation of Birds and their Habitats. The objectives pursued by project implementation were: 1) A feasibility study of a financial compensation mechanism for conservation based on good bird tourism practices in the Mashpi-Guaycuyacu-Sahuangal (MSG) area of conservation and sustainable use (ACUS) in the MDQ, 2) Training of local actors as a strategy for strengthening the implementation of a compensation mechanism based on bird watching for the MGS Natural Area in the MDQ, 3) Citrus Chain Analysis for the MGS ACUS, and 4) Training in organic agriculture to community members of the MGS and Pachijal Municipal Conservation Areas of the MDQ.

The 'My recovered stream' project, with a contribution of USD 85,000 from the Environmental Fund for the winner: the Zonal Administration of La Delicia. The objectives pursued by project implementation were: 1) Decontamination, rehabilitation and physical and environmental recovery of streams, 2) To promote a sense of belonging, ownership and co-responsibility, and 3) To implement a public participatory management model for the recovery of streams.

The 'Study of empty forest syndrome and diagnostics of the population status of tetrapod vertebrates in nine protected areas in the northwest of the Metropolitan District of Quito', with a contribution of USD 69,937.43 from the Environmental Fund to the winner, which was the Jatun Sacha Foundation . The objectives pursued by project implementation were to: 1) Contribute to biodiversity conservation and management, and the sustainable management of nine nature reserves in the northwestern MDQ, through the generation of information relating to empty forest syndrome contributing to decision-making by the environmental authority and local communities, 2) Estimate the population density of vertebrate fauna in nine nature reserves in the northwest of the MDQ, and 3) Understand the state of conservation of the forests of the nine selected nature reserves, through the presence or absence of species indicating the health of a forest.

The 'Ravines Recovery' project, the objective of which is the implementation of the Integrated Environmental Intervention Plan for the Ravines of Quito, in order to recover a portion of the Habas-Corral ravine, located between the La Pulida Habas Corral and Ana María neighborhoods in the Metropolitan District of Quito, with a contribution of USD 47,900 from the Environmental Fund to the winner, NOVUM Advisors and Consultants. The project is currently being implemented.

The 'Eco-neighborhood' project, aimed at developing strategies for the formation of the Puertas del Sol Eco-neighborhood, through environmental good practices with the active participation of inhabitants, strengthening community participation for the recovery of a public space, with a contribution from the Environmental Fund of USD 40,000 to the winner: Paúl Pasquel (engineer). The project is currently being implemented.

Abbreviations and Acronyms

Part I

CR	Critically Endangered species
EN	Endangered species
GHG	Greenhouse Gases
IBA	Important Bird Areas
INEC	National Institute of Statistics and Censuses
IUCN	International Union for the Conservation of Nature
MDQ	Metropolitan District of Quito
MECN	Ecuadorian Museum of Natural Sciences
VU	Vulnerable

Part II

CF	Carbon Footprint
Corpaire	Air Corporation
EGP	Environmental Good Practices
EMASEO-EP	Municipal Public Hygiene Company
EMGIRS-EP	Municipal Public Company for Integrated Solid Waste Management
EPMAPS	Municipal Public Potable Water and Sanitation Company
ESAQ	Ecuadorian Standard for Air Quality
Fonag	Fund for the protection of water
GHG	Greenhouse Gases
Inamhi	National Institute of Meteorology and Hydrology
INECO	Engineering and Transport Economy
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land Use Change in Land Use and Forestry
MMDQ	Municipal Metropolitan District of Quito
MTMP	Metropolitan Territorial Management Plan
QIAQ	Quitenian Index of Air Quality
Senagua	National Water Secretary
TULSMA	Unified Text of Secondary Legislation of the Ministry of the Environment
US-EPA	United States Environmental Protection Agency
USW	Urban Solid Waste
WF	Water Footprint
WMO	World Meteorological Organization

Part III

GPC	Global Protocol for Community Greenhouse Gas Emissions Inventories
ICLEI	Local Governments for Sustainability
SDG	Sustainable Development Objectives
UCLG	United Cities and Local Governments
UN	United Nations
UNO	United Nations Organization

Part IV

AAN	National Environmental Authority
AAAr	Environmental Authority responsible for Application
ABCP	Andean Bear Conservation Program
ACUS	Area of Conservation and Sustainable Use
Agrupar	Urban Participatory Agriculture
AIER	Special Area of Intervention and Recuperation
AIMS	Mariscal Sucre International Airport
APH	Wetlands Protection Area
ASRN	Areas Sustainable in Natural Resources
BITC	Business In The Community
CCQ	Chamber of Commerce of Quito
CDKN	Climate and Development Alliance
CEES	Ecuadorian Council of Sustainable Building
Cegam	Education and Environmental Management Centers
CEOA	Andean Bear Ecological Corridor
CEIS	Cohesive Environmental Information System
CEMS	Cohesive Environmental Management System
CFN	National Financial Corporation
CIP	Chamber of Industry and Production
CNBPE	National Corporation of Protected Forests of Ecuador
COAQ	Bird Watchers Collective
Comafors	Corporation of Sustainable Forest Management
Conquito	Metropolitan Agency for Economic Promotion
COOTAD	Organic Code of Territorial Organization, Autonomy and Decentralization
CVQ	Vida para Quito (Life for Quito) Corporation
DEQM	Directorate of Environmental Quality Management
EC	Ecological Corridor
Ecopar	Corporation for investigation, training and technical support for the sustainable management of tropical ecosystems
EGP	Environmental Good Practices
Emaseo	Municipal Hygiene Company
EMGIRS	Municipal Company for Integrated Solid Waste Management
EMS	(Municipal) Environmental Management System
EPMOP	Metropolitan Public Company of Public Works
EPMAPS	Municipal Public Potable Water and Sanitation Company
EPMSA	Metropolitan Public Company of Airport Services
EQCC	Quitenian Climate Change Strategy
Espoch	Chimborazo Polytechnic
FAO	Food and Agriculture Organization of the United Nations
FFLA	Latin American Future Foundation
FMM	Forest Management Model
Fonag	Fund for the protection of water
ICU	Urban Connectivity Index

INIAP	National Agricultural Research Institute
IPCC	Intergovernmental Panel on Climate Change
IVU	Urban Green Index
HNAE	Heritage of Natural Areas of Ecuador
MAE	Ecuadorian Ministry of the Environment
MEDSQ	Metropolitan Environmental Distinction: Sustainable Quito
MFS	Sustainable Forest Management
MOF	Map of Forest Management
PROFAFOR	FACE Forestation Program of Ecuador
RIABM	Ibero-American Network of Model Forests
RPAAFF	Recovery Plan for Areas Affected by Forest Fires
SMAP	Subsystem of Metropolitan Protected Areas
TNC	The Nature Conservancy
TULSMA	Unified text of Secondary Legislation of the Ministry of the Environment
USFQ-CTT	San Francisco de Quito University –Center of Transfer and Technology
UGN	Urban Green Network
UTN	Technical University of the North
WRP	Water Recovery Plant
ZA	Zonal Administration
ZAT	Zonal Administration Tumbaco

Glossary

INTEGRATED WASTE MANAGEMENT

MDQ Hygiene and cleaning services: Hygiene and cleaning services provided by the public company EMASEO-EP.

Collection and transport Services for Domestic and sanitary waste: EMASEO-EP performs services of collection and transport to the Transfer Stations and waste dumps of the different areas of North, Central and South of the Metropolitan District of Quito as well as in the parishes where collection hasn't been decentralized.

Ordinary sidewalk collection: Service of solid waste collection that is provided on public roads to collect waste deposited in bags without containerization and placed in front of the access to the building, according to the schedule preset by the Municipality.

Ordinary mechanized collection: Service of solid waste collection that is provided on public roads for the collection of waste deposited in containers, under or above ground, in the vicinity of the homes, which can be deposited regardless of the time that the municipality establishes for the emptying of containers.

Separate collection: collection of bulky solid waste (furniture): Service performed by EMASEO-EP corresponding to the collection of bulky waste, provided by the company free of charge and through boxes installed at the Western and Forest Operation Centers, where the company receives diverse materials.

Clean points: Clean points usually have adequate, safe and accessible containers for the temporary storage of non-hazardous household waste, such as paper, cardboard, plastic and glass, among other recyclable materials, in: shopping centers, gas stations, supermarkets, universities, schools and colleges that have the necessary space and safety for hazardous household waste such as batteries, fluorescent bulbs, among others. There are more than 400 collection points spread across the MDQ.

Collection from large generators of waste: This service is for the benefit of generators of large quantities of waste in the Metropolitan District of Quito, such as multifamily residences, housing complexes, markets, shopping malls, schools, universities and companies in general. For this type of collection front-loading collectors, dump trucks, roll off trucks and 3 cubic meters boxes installed at collection points are currently being used.

Collection of non-hazardous industrial waste: This service performs the collection of non-hazardous waste from MDQ industries.

Collection and transport of medical waste: This service is provided by the EMGIRS-EP company and consists of the collection and transport of medical waste in the MDQ.

Public cleaning services:

Mechanical / manual sweeping: The mechanical sweeping service is performed by using mechanical sweepers on sidewalks, central flower beds and main roads with high public transit and traffic. Conversely, manual sweeping is the service performed in front of private property as well as in parks. For the performance of this service collection cars and garbage bags are used.

Pressure washing: This service washes and cleans both damp and dirty places that need further treatment with pressurized water at different points of the MDQ: sidewalks, roads, plazas and heavily soiled areas.

Cleaning of critical points: Another cleaning service corresponds to the cleaning of certain points where an irregular accumulation of waste is generated. This service is linked to the Citizen Control Project in which the community participates through 'neighborhood workdays'.

Cleaning of emblematic parks: Permanent cleaning of 57 emblematic parks in the MDQ, which includes sweeping and collection of waste generated.

Special cleaning services:

Cleaning for public or private events: Service provided by the EMASEO-EP company before, during and after public and private events. Besides cleaning, lavatory facility rentals are made for such events.
Cleaning of Markets and fairs: Cleaning 54 markets and 8 fairs by sweeping and collection of waste generated by businesses.

Treatment and final deposit services:

EMGIRS-EP performs the admission and treatment of Municipal Solid Waste (MSW) in the North and South Transfer Stations, as well as integrated management of medical waste through collection and treatment, the final disposal of MSW from the MDQ, the Municipality of Rumiñahui, and of sanitary waste in the El Inga Landfill Site, and also the final disposal of CDW (debris) from the MDQ in the Troje 4 and Piedras Negras tips, which is transferred by the EMASEO-EP company, individuals and the Quito Metro Project.

Treatment, utilization and final disposal of Sanitary Waste: The service of medical waste treatment is performed by the sterilization of waste in the Sanitary Waste Treatment Plant, where around 11.4 tons of medical solid waste is treated daily. The final disposal of medical waste is in a specific cell for solid sanitary waste at the El Inga Landfill Site.
Public treatment, transportation and disposal of household solid waste service: the service of transfer, transportation and disposal of non-hazardous solid waste from households is performed by the EMGIRS-EP company, which also performs leachate treatment, treatment and utilization of gas and utilization of solid waste that is potentially recyclable. These services are provided in the North and South Transfer stations and the El Inga Landfill Site. This service is provided to sporadic ordinary users who submit waste a maximum of 3 times a year and to continuous users who receive authorization from EMGIRS-EP's Coordination of Health, Safety and the Environment.
Final disposal in tips: The disposal service of Construction and Demolition Waste (debris) in the El Troje 4 and Piedras Negras tips is performed by the EMGIRS company for those occasional users wishing to deposit non-hazardous debris up to three times a year, in accordance with the existing rules on receiving waste. In addition, there may be users who continuously deposit debris linked to an economic activity, these users must request authorization from EMGIRS-EP's Coordination of Health, Safety and the Environment.

NATURAL HERITAGE

Area of Conservation and Sustainable Use (ACUS): These areas are covered by native vegetation and have high biological importance given the biodiversity generated by the various climatic zones present, as well as high endemism due to biophysical conditions. Its terrain is very rugged, which is a limiting factor for agriculture and livestock. However, there is an extended patch of crops and pastures along the main access roads and the smaller rivers that cross them.
Area of Special Intervention and Recovery (AIER): These areas are mainly covered by planted forests (eucalyptus, cypress or pine) and by dispersed native shrubs and herbaceous vegetation. Despite having slopes ranging from medium to steep, there is currently a high pressure to occupy these areas, mainly for the creation of developments and homes, which puts pressure on the communal territories in these areas and on the planted forests that perform the role of slope protection.
Residential Agriculture: Corresponds to those areas and concentrated or dispersed human settlements, linked to activities in agriculture, livestock, forestry and fishing.
Environment: Set of phenomena or natural and social elements surrounding an organism, and to which the organism responds in a certain way. These natural conditions may be other organisms (biotic environment) or non-living elements (climate, soil, water). As a whole these condition the life, growth and activity of living organisms.
Environmental goods: These are the tangible resources used by humans as inputs in production or for final consumption and which are spent and transformed in the process, such as wood, fruit, animal skins, meat, seeds, medicine, among others, and are used by humans for consumption or marketing.
Biodiversity: Diversity of plant and animal species living in a given space.
Bioregion: Territory of water and land whose boundaries are defined not by political boundaries, but by the geographical boundaries of human communities and ecosystems.
Andean Bear Ecological Corridor (CEOA): Approved by the Metropol-

itan Council of Quito on June 20th 2013, and sanctioned by Mayor Dr. Augusto Barrera on July 10th 2013, through Resolution No. C431. This declaration is a mechanism to conserve and protect the habitat of emblematic but endangered wildlife species, and other species of flora and fauna associated with the Andean forest, as well as to promote harmonious development with the environment, making the sustainable management of natural resources viable, and in turn, to create opportunities for a good life for local populations.

Watershed: Portion of land defined as a place where waters run continuously or intermittently to a larger river, lake or sea.

Endemism: Indicates the distribution of a group of organisms limited to a small geographical area and not found naturally anywhere else in the world.

Flora: Refers to all plants that can be found in a geographic region that are characteristic of a geological period or inhabiting a particular ecosystem.

Fauna: The set of animal species that inhabit a geographic region.

Social forestry: Refers to the set of theories, policies and activities based on interactions between people and natural resources that have the improvement of emotional, social, economic and ecological needs of local communities as their main purpose.

Habitat: Place or ecologically homogeneous area where a particular plant or animal breeds.

Important Bird Area (IBA): The areas recognized internationally for their importance for bird conservation, declared in order to combine environmental conservation and social development with a focus on sustainability, due to the presence of species of birds which are globally threatened, have restricted ranges or are endemic.

Sustainable Forest Management: Defined by the FAO as a dynamic and evolving concept that aims to preserve and enhance the economic, social and environmental values of all types of forest for the benefit of present and future generations.

Plan of Use and Occupancy of Land (PUOL): A normative instrument for development planning of the Metropolitan District of Quito, which aims to order, reconcile and harmonize the decisions of the Metropolitan District of Quito's Metropolitan Development Plan regarding human settlements, economic and productive activities and the management of natural resources based on territorial qualities.

Sustainable production: A set of activities performed particularly in rural areas to obtain certain goods or services with the intent to sell them, these are characterized by certain forms of use of local natural heritage (management system) and do not progressively degrade production capacity. Such activities can be productive (cultivation, collection, use, mining, grazing) or managerial (prevention, maintenance, restoration). Production systems can be: sustainable coffee farming, sustainable cocoa production, sustainable beekeeping, silvopastoral forestry, use of wildlife and ecotourism. These production systems were identified by their role in biodiversity conservation and their market potential. Also included is the application of agricultural, livestock, and other 'best practices'.

Agroforestry systems: A set of practices and production systems, in which the planting of crops and forest trees is sequential and in combination with the application of soil conservation practices.

Silvopastoral systems: The combination of fruit or forest species and animals without the presence of crops. These systems are practiced at different levels, from large commercial tree plantations which include cattle, to the grazing of animals to supplement subsistence agriculture. If animal stocking is high, soil compaction can affect the growth of trees and other associated plants.

Ecological Protection/Conservation of Natural Heritage Use: Land destined for conservation and preservation of natural heritage.

Industrial use: Land intended for use in production, processing, treatment and handling of raw products to produce goods or materials.

Multiple uses: Assigned to the properties fronting certain roads or located in downtown areas in which compatible residential, commercial, service and amenities, and low-impact industrial activities can be developed and implemented.

Natural resources/Sustainable Production Use: Corresponds to the areas allocated for the development of forestry, farming and fishing, and mining activities for the extraction of aggregates and stone for construction.

Residential use: The main activity is housing with the development of amenities and complementary commercial and services activities. The combination of residential use with other uses and activities shall be determined according to the levels of compatibility with PUOL or other planning tools.

Food security: Availability at all times of adequate supplies of basic foodstuffs to counteract fluctuations in production and prices.

Environmental service: Each of the utilities that nature provides to humanity as a whole, or to a local population, from an economic point of view.

Environmental services: Benefits that people obtain from ecosystems. **These benefits include:** supplies of water and food, regulating cycles such

as floods, land degradation, desiccation and salinization, pests and diseases, the functioning of ecosystem processes that generate direct services, such as photosynthesis and the formation and storage of organic matter, nutrient cycling, the creation and assimilation of soil and neutralization of toxic waste, aesthetic, spiritual and cultural values, or recreational opportunities.

CLIMATIC CHANGE AND SUSTAINABILITY

Adaptation: Adjustment of natural or human systems to new or changing environments. Adaptation to climate change refers to adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderate harm or exploit beneficial opportunities. We can distinguish various types of adaptation, among these being preventative and reactive, private and public, and autonomous and planned.
Business as Usual (BAU): Scenario without introducing changes, the plausible representation of the future development of emissions of greenhouse gases based on a consistent set of assumptions about the forces that drive them and the assumption that operating practices and policies remain the same as today.
Climate change: Important statistical variation in the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes, changes forced by external factors, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.
It should be noted that the Framework Convention of the United Nations on Climate Change (UNFCCC), in its Article 1, defines ‘climate change’ as: “a change in climate directly or indirectly attributed to human activity that alters the composition of the world’s atmosphere and is in addition to natural climate variability observed over comparable time periods”. The UNFCCC distinguishes between ‘climate change’ attributable to human activities altering the atmospheric composition, and ‘climate variability’ attributable to natural causes.
Capacity building: In the context of climate change, the process of development of experience or technical skills and institutional capacities in developing countries and economies in transition to enable them to effectively address the causes and consequences of climate change
Sustainable Development: Development that meets the cultural, social, political and economic needs of the present generation without endangering the ability of future generations to meet their needs.
Vector-borne diseases: Diseases transmitted to hosts by a vector organism such as a mosquito or tick (e.g. malaria, dengue fever and leishmaniasis).
Exposure: The type and degree to which a system is exposed to significant climatic variations.
Greenhouse gas (GHG): Gaseous component of the atmosphere, both natural and anthropogenic, that absorbs and emits radiation at specific wavelengths in the spectrum of thermal infrared radiation emitted by the Earth’s surface, by the atmosphere itself and by clouds. This property causes the greenhouse effect. Water vapor (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are the primary greenhouse gases in the Earth’s atmosphere.
Impacts (climate change): Effects of climate change on natural and human systems. Depending on whether a process of adaptation is considered, one can distinguish between potential impacts and residual impacts.
Emissions Inventory: The quantification of total GHG emissions from five sectors of analysis.
Adaptation measures: These are concrete actions that seek to reduce vulnerability. Given the climate change scenarios available in the present, these adaptation measures are essential for social systems to respond to the projected impacts.
Mitigation (of climate change): Human intervention to reduce the sources or enhance the sinks of greenhouse gases.
Resilience: Absorb an alteration without losing the same basic structure, modes of operation, the capacity for self organization or the ability to adapt to stress and change.
Sensitivity: The degree to which a system is affected, positively or negatively, by climate variability or change. The effects may be direct (for example, a variation of crop yield in response to a variation of the average temperature, the ranges of temperature or temperature variability) or indirect (for example, damage caused by an increased frequency of coastal flooding as a result of a rise in the sea level).
Sustainability: The existence of economic, ecological, social and political conditions that determine the harmonious functioning of a system over time and space. It refers to the balance that exists in a species based on its environment and all the factors or resources it has to make the functioning of all its parts possible, without sacrificing or damaging the capabilities of the environment.
Climate variability: Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond

certain phenomena. Variability may be due to natural internal processes within the climate system (internal variability), or to external anthropogenic forcing variations (external variability) (See also Climate Change).
Vulnerability: The level at which a system is susceptible, or is not able to withstand, the adverse effects of climate change, including climate variability and extreme phenomena. Vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

ENVIRONMENTAL GOOD PRACTICES

Environmental Good Practices (EGP): The set of simple actions that involve a change in attitude and behavior of people in order to have a friendly relationship with the environment.

Waste characterization: The activity identifying the type of waste generated and measuring the weight and volume of such waste. This activity can be done at household, neighborhood, institution or company level.

Metropolitan Environmental Distinction Sustainable Quito (MED SQ): Public recognition performed every year since 2015 by the Secretary of the Environment, and given to the people, neighborhoods, businesses and institutions that implement environmental good practices to reduce their footprints. **It involves the evaluation of a number of qualitative indicators classified for:** 'Sustainable Mobility', 'Environmental Good Practices to reduce footprints', 'Care for Natural Heritage', 'Adequate Management of Waste' and 'Sustainable Construction'.

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